Model G-22

Dual Channel Recorder

Technical Information from the Varian Associates Instrument Division.

VARIAN

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INSTRUCTION MANUAL

Model G-22

Dual Channel Recorder

VARIAN associates
INSTRUMENT DIVISION

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Figure 1-1: Model G-22 Dual Channel Recorder

1.0 INTRODUCTION

1.1 SUMMARY

The Varian Model G-22 is a dual-channel strip chart recorder. It contains a chart drive system, a pen and ink system, and two mechanically and electronically independent recording channels. Operation is based upon the null balancing method incorporating a closed-loop servo system. The unit is constructed along modular lines, utilizing plug-in assemblies for compactness, and convenience in service and maintenance. A variety of input chassis types, each designed to accept different forms of input signal information, is available. The standard Model G-22 Recorder is available in a wide range of chart speeds. A chart speed shifter external to the chart drive motor provides two chart speeds in each motor speed range. If desired, the recorder can be supplied with two chart drive motors, providing four chart speeds. The pen and ink system is comprised of capillary pens and large ink reservoirs, allowing prolonged operation without refilling. The Model G-22 is housed in a die-cast aluminum portable case which may be panel mounted.

1.2 APPLICATION

The Model G-22 Recorder can be used for correlation and simultaneous readout of two independent functions. It will record any phenomenon which can be transduced to a d-c voltage or current. The unit does not load the measured source appreciably, and signals with currents in the microampere range are measurable.

1.3 EQUIPMENT SUPPLIED

Basic equipment supplied with the Model G-22 Recorder in portable or panel-mounted forms includes the following items:

1. Two pens with capillary tubes
2. Two ink reservoirs
3. Three pen cleaners
4. One roll of chart paper
5. One re-roll tube
6. Two spare reference cells (if used)
7. One bottle each of red and blue ink
8. One instruction manual

1.4 GLOSSARY OF TERMS

The following are standard industry terms used to specify recorder performance, and will be used in this manual.

SPAN: the algebraic difference between the top scale value and the bottom scale value, expressed in scale units.

LIMIT OF ERROR: the difference between indicated and true value of the quantity being measured, expressed in percent of span.

DEAD BAND: the range through which the measured quantity may be varied without instrument response.

FULL SPAN BALANCING TIME: the time required for the instrument to achieve a full-scale change with application of a full-span step input.

1.5 G-22 SPECIFICATIONS*

FULL SPAN BALANCING TIME
One second with full-span step input

CHART SPEEDS

Basic speed (Shifter in HIGH)	*2nd speed (Shifter in LOW)*
½ inch per hour	⅛ inch per hour
1	¼
2	½
3	¾
8	2
12	3
15	3¾
20	5
24	6
30	7½
1 inch per minute	15 inches per hour
2	30
4 inches per minute	1 inch per minute
6	1½
8	2
12	3
16	4

POWER REQUIREMENTS
110 vac - 120 vac, 58 - 62 cps, 65w, single phase
220 vac - 240 vac, 58 - 62 cps, 65w, single phase

TUBE COMPLEMENT
2 - 12AX7, 2 - 6AQ5

DIMENSIONS
Height: 12⅝ inches (approx.) with rubber feet and handle, 10¾ inches less feet and handle
Width: 9½ inches overall, including hinges, 8¾ inches, panel mounting width
Depth: 13⅜ inches overall

WEIGHT
33 lbs., incl. input chassis

*These specifications apply only to the Model G-22 main recorder assembly, and do not include chassis specifications. Refer to appropriate input chassis section in Section 2 for full specifications and tube complement.

1.6 ACCESSORIES

Accessory equipment includes optional input chassis, adjustable event markers and alarm contacts for both channels, retransmitting potentiometers ganged to the balancing potentiometer shaft, and side-by-side pens for zero time displacement between channels. A 19-inch rack panel with appropriate panel-mounting cutout, and a special dual mounting case for two Model G-22 recorders which may be mounted in a 19-inch rack are available. An input chassis test extension cable is supplied on order, allowing access to input chassis wiring and test points during operation.

description of units

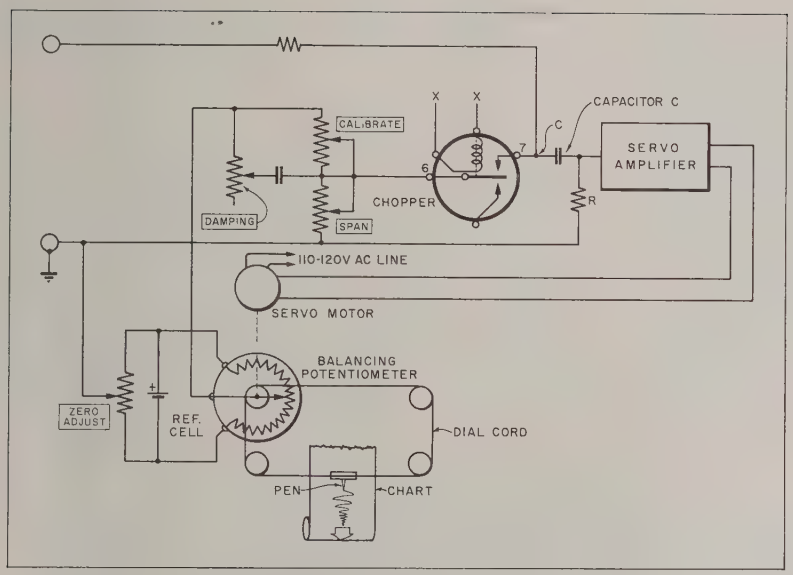


Figure 2-1:
Composite Diagram of Model G-22

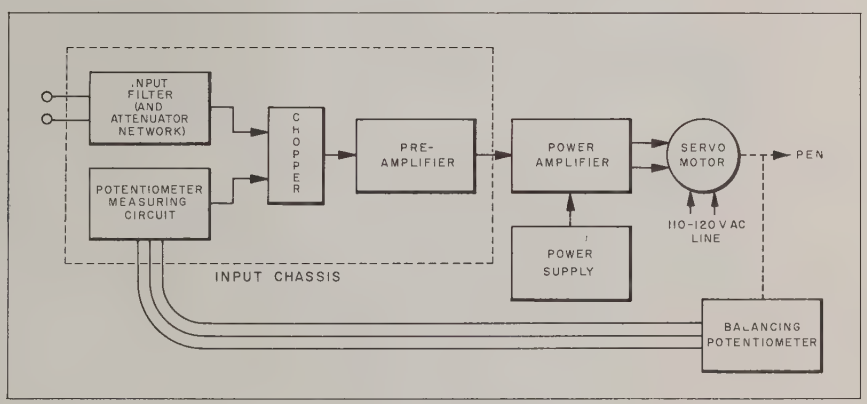


Figure 2-2:
Block Diagram of Model G-22

2.0 DESCRIPTION OF UNITS

2.1 INTRODUCTION

The plug-in *input chassis* provide the signal control and adjustment functions of the recorder, plus conversion, attenuation, pre-amplification, and other conditioning of input signals. The *main recorder* assembly contains the balancing potentiometers, servo systems, servo amplifier sections, power supplies and pen systems for both channels, as well as the chart transport system, chart-transport controls, and power controls.

2.2 DESCRIPTION OF SYSTEM OPERATION

The Model G-22 Recorder employs a closed-loop servo system. Through mechanical and electrical components, the input-signal voltage is translated into a proportional physical movement of pen-positioning elements. Figure 2-1 is a composite diagram of the system, Figure 2-2 a block diagram. A high-resolution, precision potentiometer is used as the electro mechanical "translating" element. This is called the *balancing potentiometer*. Its shaft is attached to the servo motor and to a drum (sheave) around which the pen dial-cord is wrapped. The system operates as follows:

A precise *measuring voltage* derived from a battery or an electronic reference voltage supply is compared to the *input-signal* voltage. This is accomplished at point C of Figure 2-1 by chopper action. The chopper, operating at power-line frequency, has a 50% duty cycle (contacts six and seven are open 50% of the time). During the open period of the chopper cycle, capacitor C charges to the input-signal potential. There is no d-c current through C due to capacitor current blocking, hence no voltage across R. When chopper contacts six and seven close, however, the *measuring voltage* sums algebraically with the *input signal voltage* at point C. If the two voltages are equal and of opposite polarity, null balance is achieved. If they are unequal, the difference voltage, known as the error signal, appears across R as capacitor C charges or discharges. This action occurs at line frequency (the chopper rate). The *error signal* is then amplified by the servo amplifier and applied to the two-phase servo motor. Direction of servo motor rotation depends on balancing signal phase. The motor rotates the balancing potentiometer shaft, hence the drum (sheave) around which the pen dial-cord is wrapped. The direction of rotation is always toward a zero error signal. When this is reached, servo action stops until a change in the input signal occurs. Meanwhile the pen has traced an analogous graph on the chart roll, which has been moved forward at a selected rate by the chart drive system.

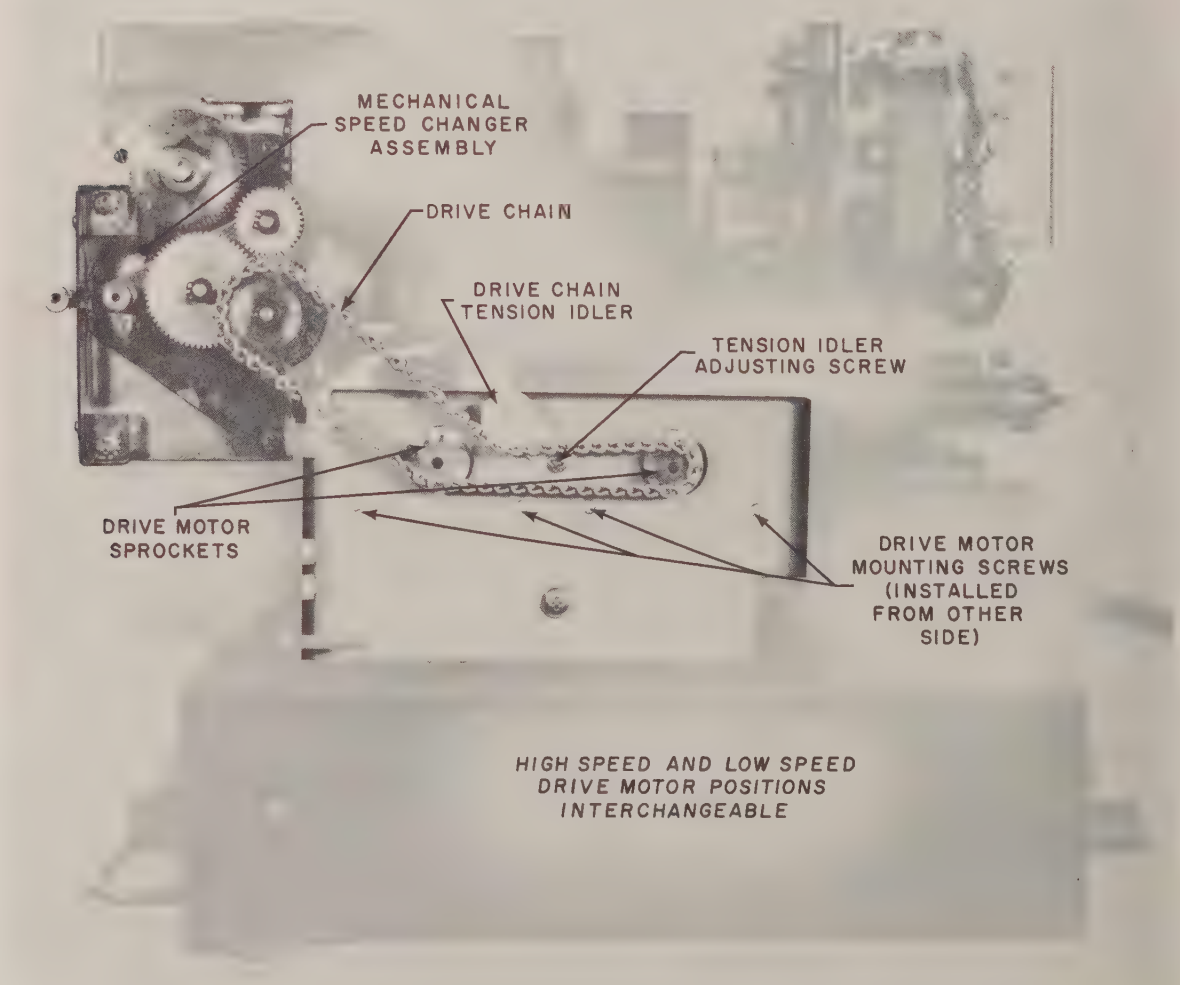

MECHANICAL SPEED CHANGER ASSEMBLY
DRIVE CHAIN
DRIVE CHAIN TENSION IDLER
TENSION IDLER ADJUSTING SCREW
DRIVE MOTOR SPROCKETS
DRIVE MOTOR MOUNTING SCREWS (INSTALLED FROM OTHER SIDE)
HIGH SPEED AND LOW SPEED DRIVE MOTOR POSITIONS INTERCHANGEABLE

Figure 2-3: Chart Drive System

2.3 RECORDER COMPONENT UNITS

All items described in Section 2.3 are contained in the main recorder assembly.

2.3.1 CHART DRIVE SYSTEM

Figure 2-3 details the chart drive system. The standard Model G-22 is supplied with one chart drive motor, but may be supplied with two motors if desired. Motors are of single-speed, synchronous type with gear-head output. When the Model G-22 Recorder is ordered with two drive motors, motors are selected by the HIGH–LOW–STDBY–OFF switch for high or low-speed operation. A mechanical gear shifter, the HIGH–N–LOW control, provides an additional four-to-one speed reduction in each motor-speed range, making a total of four different speeds. For chart speeds of 12 inches per minute and above, two motors operating in parallel are required, allowing only two speeds, the basic speed and that obtained through the gear-shifter reduction. In all cases, when basic chart speeds are to be changed, the chart drive motors must be changed.

2.3.2 PEN SYSTEM

Figure 2-4 details the pen drive systems, methods of coupling pens to balancing-potentiometer sheaves, and shows correct ink reservoir position. Capillary pens, connected to the ink reservoirs by plastic feed tubes, are used. Reservoir height may be adjusted to control ink flow to suit the recording rate. See Section 3.4.

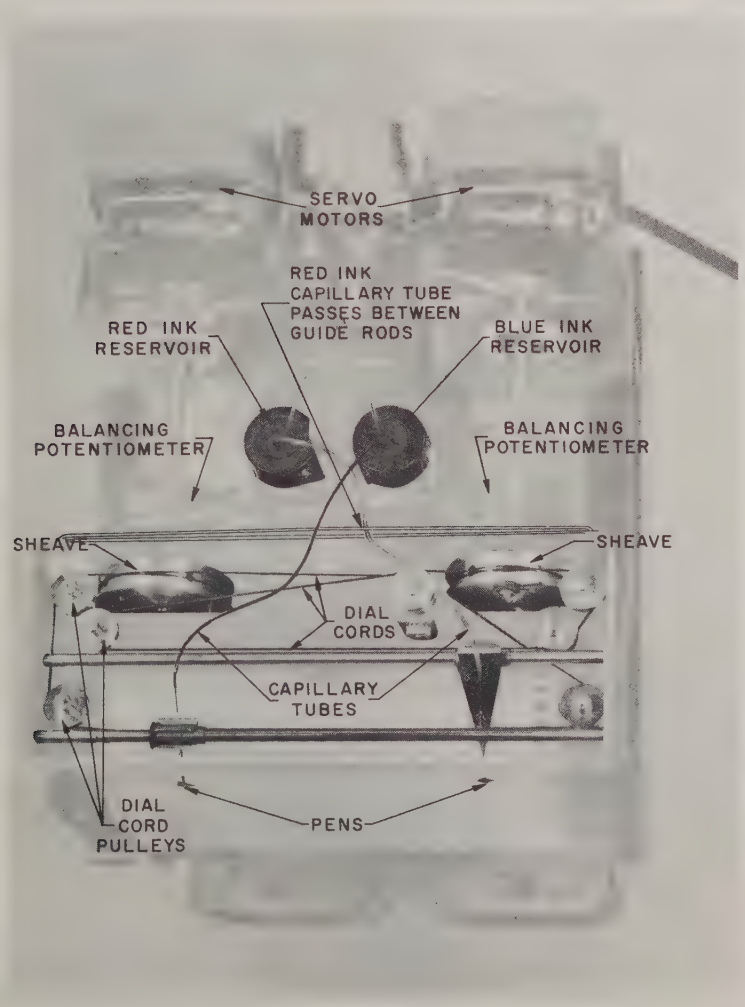


Figure 2-4: Pen Drive System

2.3.3 POWER SUPPLIES

Figure 2-5 is the power supply schematic. Two independent power supplies mounted on a common chassis are used. Both utilize silicon rectifiers in a bridge circuit with capacitor-input filtering, and operate from the 110v, 60-cps line through step-up transformers (50-cps operation available). Series connection of transformer primaries permits operation from the 220v line if desired. Use of independent power supplies allows each recording channel to operate simultaneously at different potentials above chassis ground.

2.3.4 SERVO AMPLIFIERS

Figure 2-6 is the servo amplifier schematic. The servo amplifiers are constructed on plug-in printed-circuit boards and consist of three amplifying stages, V302A, V302B, and V303. Interstage bandpass networks provide maximum response over a frequency range centered about 50 - 60 cps. Maximum available gain is greater than 2 x 10^6. The error signal is first amplified in the input chassis, then by V302A and V302B in the servo amplifier and last by V303, a beam-power tube which energizes the servo motor control winding through auto transformers T501 or T502.

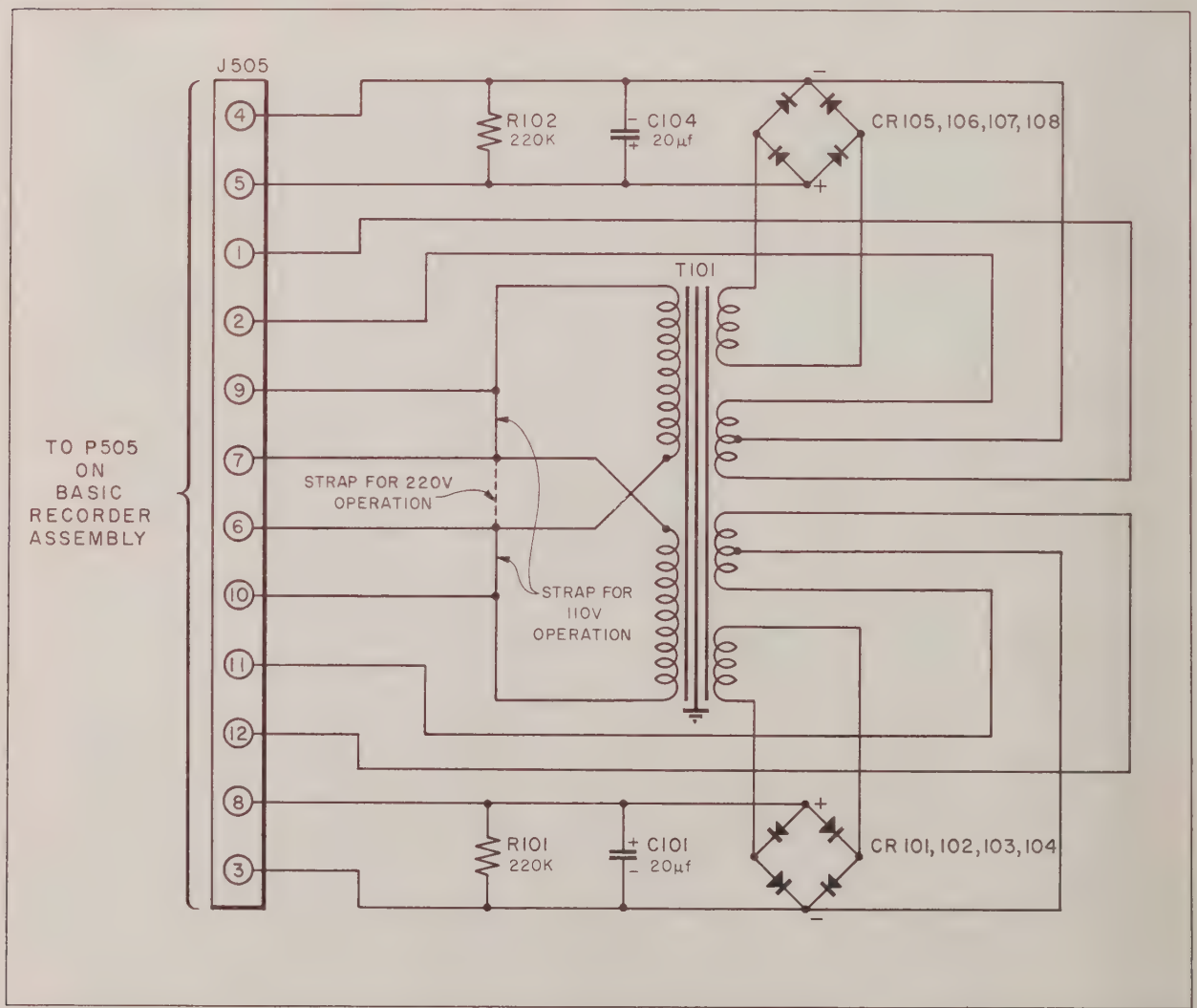


Figure 2-5: Power Supply Schematic

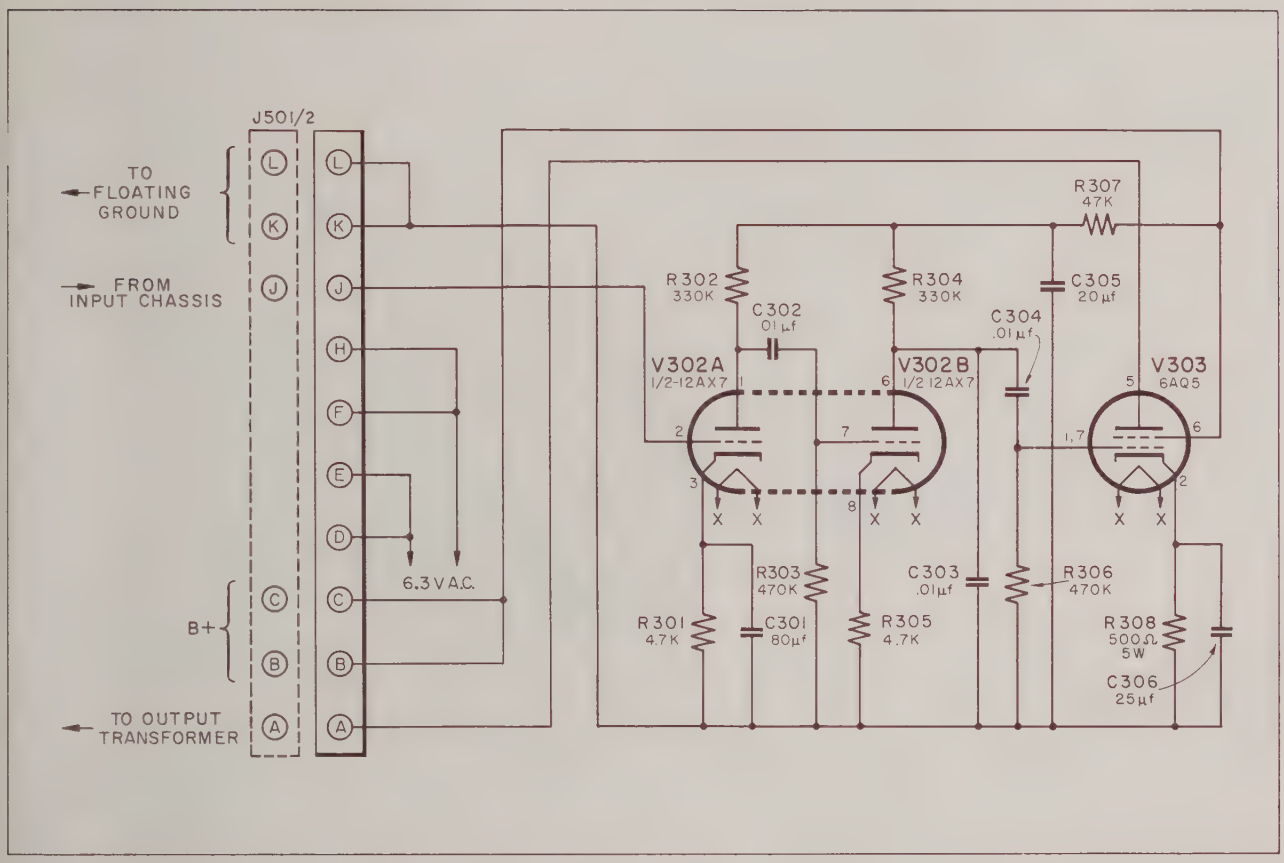


Figure 2-6: Servo Amplifier Schematic

2.3.5 SERVO MOTORS

The servo motors are two-phase, reversible induction motors designed for 60-cps operation. Two windings are used. One is excited by the power line, the other, the control winding, by the servo amplifier. Maximum torque is achieved when a phase difference of 34° is reached between winding current and power line current. Because the servo motors are phase sensitive over a limited frequency range, variations in control current at other than line frequency have no effect on operation. The motors are mechanically damped for best performance, and are also equipped with a mechanical stop to limit pen travel.

2.3.6 CONTROLS

The Model G-22 main recorder assembly contains the following controls:

HIGH–N–LOW gear shifter–this control provides a four-to-one chart speed reduction between High and Low. N is a neutral position.

HIGH–LOW–STDBY–OFF switch–this switch controls recorder power, and when the recorder is supplied with two chart drive motors, selects the low- or high-speed motor. In STDBY amplifiers are on, and only the control winding of the servo motor is energized. In LOW and HIGH the low- and high-speed chart drive motors, respectively, are operative, and the line winding of the servo motor is energized. If only one chart motor is supplied, it operates in HIGH only.

2.4 TYPE A-21 INPUT CHASSIS

The Type A-21 Input Chassis contains adjustments which permit the recording of input signals from 10 mv to 100 mv with full-span pen deflection. The Type A-21 uses a mercury cell as the reference voltage source. Figure 2-7 is the A-21 Input Chassis schematic.

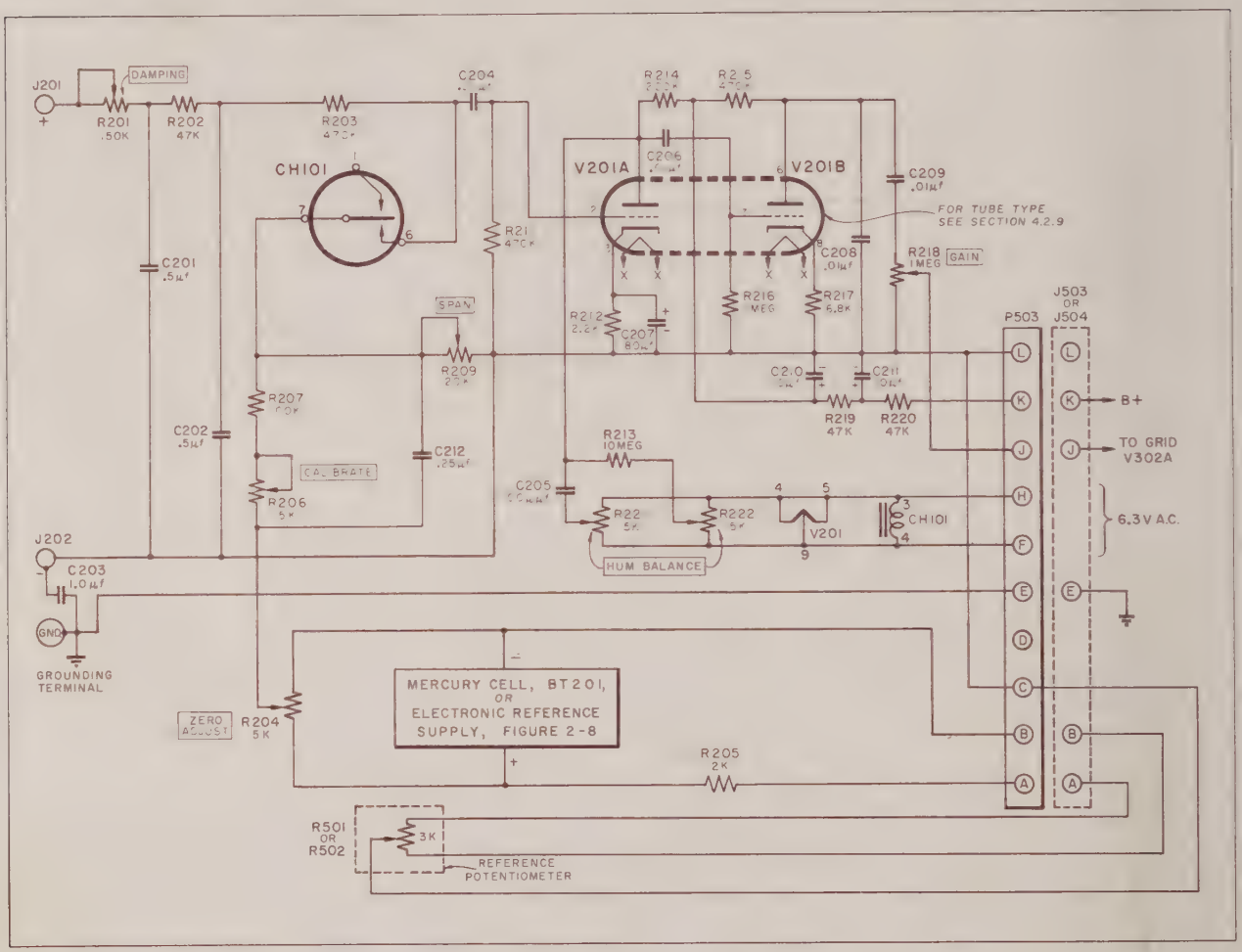


Figure 2-7: Type A-21 Input Chassis Schematic

2.4.1 A-21 SPECIFICATIONS

INPUT

Impedance:	Approaches infinity at null, greater than 500k ohms minimum off null
Permissible source resistance:	10- to 20-mv span range: 50k ohms maximum 20- to 50-mv span range: 75k ohms maximum 50- to 100-mv span range: 100k ohms maximum
Span:	10 mv to 100 mv, adjustable, for full span deflection
Polarity:	Positive-going signals cause left-to-right pen travel
LIMIT OF ERROR	1% of full span
BALANCING TIME	One second with full-span step input
TUBE COMPLEMENT*	1–12AU7 for spans from 50-100mv 1–12AT7 for spans from 20-50 mv 1–12AX7 for spans from 10-20 mv

* See Section 4.2.9

2.4.2 DESCRIPTION OF CIRCUIT

The Type A-21 Input Chassis schematic is shown in Figure 2-7. The Type A-21 contains a low-pass input filter, an isolation network, a two-stage amplifier, a chopper and a reference circuit. The input signal appears at C204 when chopper contacts six and seven are open. When these contacts are closed, the reference voltage appears across R206 and R207, summing with the input signal at C204. If the two voltages differ, C204 charges or discharges, and an error signal appears across R211. This signal is then amplified and applied to the servo amplifier.

2.4.3 CONTROLS AND ADJUSTMENTS

The Type A-21 Input Chassis contains the following controls:

ZERO ADJUST control

The ZERO ADJUST control, R204, is shown in Figure 2-7. This control shifts the zero-voltage point along the balancing potentiometer slidewire, hence the zero position of the pen. It is usually adjusted so the pen is at the zero point on the chart with no signal input, but may also be used to adjust the pen for zero center operation, or any desired zero point on the chart.

DAMPING control

As the servo motor turns the balancing potentiometer toward zero error position, system inertia causes the servo motor and potentiometer to overshoot the zero error position. Capacitor C212 provides a fixed damping constant to overcome this tendency, by creating a condition in which current leads voltage, the amount of current lead being sufficient to create an "apparent null" before null is actually reached. Variable resistor R201, the DAMPING control, is a fine adjustment. This adjustment should be made before the recorder is calibrated, and should not be changed. A mechanical damper is also used on the servo motor. See Section 4.2.4. for details of the mechanical damper.

CALIBRATE control

R206, the CALIBRATE control, provides a fine, series adjustment of the voltage from the reference source to compensate for the slight decay of mercury cell voltage with time, and to provide a fine span adjust.

SPAN control

R209, the SPAN control, adjusts the amplitude of the measuring voltage appearing at the chopper contact, therefore determining the maximum input signal to the recorder which can be properly nulled.

GAIN control

When span is changed to accommodate signals of different full-scale amplitude, the resulting balancing signal has a correspondingly different amplitude. By means of the GAIN control, R218, the balancing signal may be adjusted to the level required for optimum system performance. See Section 4.2.4.

HUM BALANCE control

Because the balancing signal alternates at the power-line rate (the chopper frequency), appearance of hum at power line frequency in the low-level stages of the system will result in d-c offset or error. A hum-bucking network across the filament supply composed of R213, R221, R222, and C205 injects a hum-bucking signal directly into the first plate circuit. Variable resistors R221 and R222 permit amplitude and phase adjustment of the hum-bucking signal for best hum cancellation. See Section 4.2.10.

2.5 TYPE A-22 INPUT CHASSIS

The Type A-22 Input Chassis is identical to the Type A-21 Input Chassis except that Type A-22 uses an electronic reference voltage supply instead of a mercury cell. With this exception, all instructions, specifications, and general circuit data for the Type A-21 apply to the Type A-22.

2.5.1 DESCRIPTION OF ELECTRONIC REFERENCE VOLTAGE SUPPLY CIRCUIT

The electronic reference voltage supply is constructed on a separate printed circuit board. Figure 2-8 is the electronic reference voltage supply schematic. The unit includes a transformer, a bridge rectifier, a filter and a Zener-diode voltage regulator used in a bridge arrangement. Resistance values are chosen to form a balanced bridge which includes the dynamic resistance of the Zener diode. R404 is a variable resistor *adjusted at the factory* so that the diode bridge will match the dynamic resistances of individual diodes. Such an arrangement provides excellent regulation of the reference voltage with line-voltage variations. The use of an electronic reference voltage supply eliminates the necessity of periodically changing the mercury reference cell, and correcting for the decay of cell voltage.

2.5.2. A-22 SPECIFICATIONS

The operational specifications of the Type A-22 Input Chassis are identical to those of the Type A-21 Input Chassis.

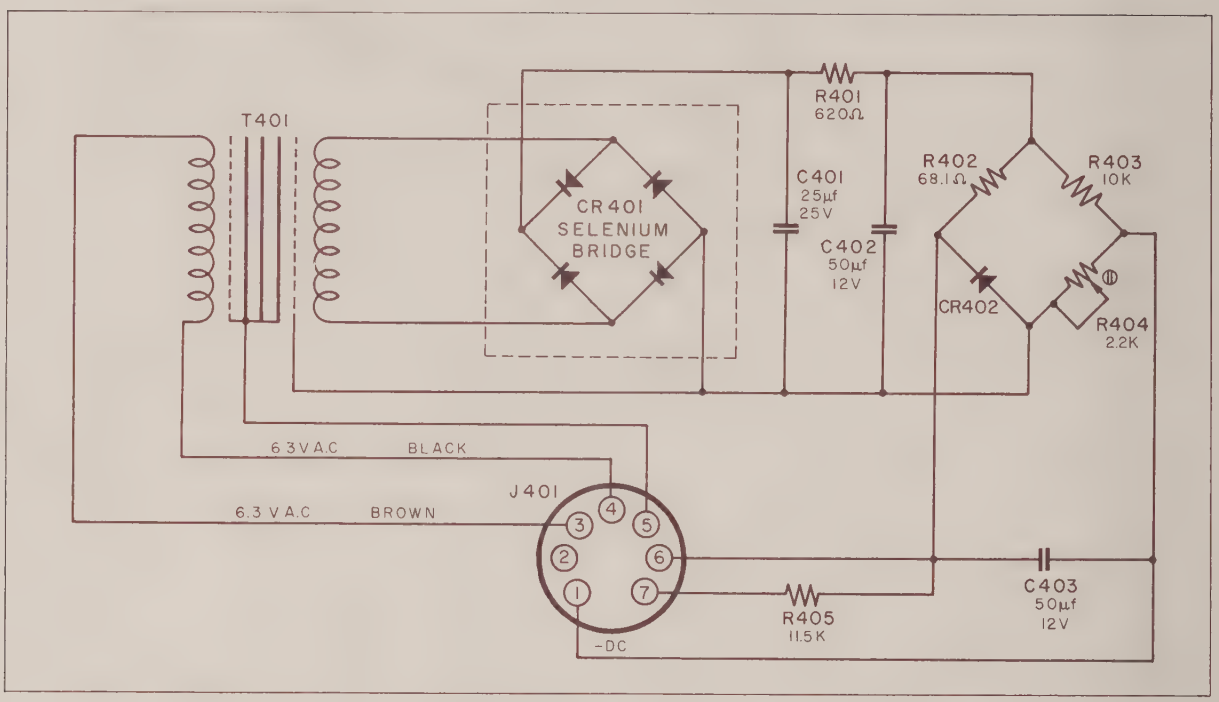


Figure 2-8: Electronic Reference Voltage Supply Schematic

2.6 TYPE B-22 WIDE RANGE INPUT CHASSIS

The Type B-22 Input Chassis contains the basic circuitry of the Type A-22 Input Chassis including the electronic reference voltage supply. Refer to Type A-21 for description of controls and adjustments, except for the attenuator or VOLTS switch and the RANGE VERNIER which allow the recording of voltages from 10 mv to 500v with full-span deflection. These controls are described below.

2.6.1 B-22 SPECIFICATIONS

INPUT

Impedance:	*10-mv span*—approaches infinity at null 500k ohms minimum off null *20-mv through 1-v spans*—100k ohms *10-v span range*—1 megohm *100-v span range*—10 megohms
Permissible source resistance:	*10-mv span range*—50k ohms maximum *All other span ranges*—no limitation imposed by input chassis. See above input impedances for possible effect on source.
Voltage range:	Zero to 500 vdc, continuous, for full-span deflection
Polarity:	Positive-going signals cause left-to-right pen travel
LIMIT OF ERROR	*10-mv span range*—1% of full span *All other spans*—2% of full span
SPAN	10 mv to 100v in nine selectable ranges: 10, 20, 50, 100, 200, and 500 mv, and 1, 10, and 100 vdc A VERNIER control allows continuous span adjustment between fixed ranges, with spans up to 500v in the 100-v position.
FULL SPAN BALANCING TIME	One second
TUBE COMPLEMENT	1–12AX7

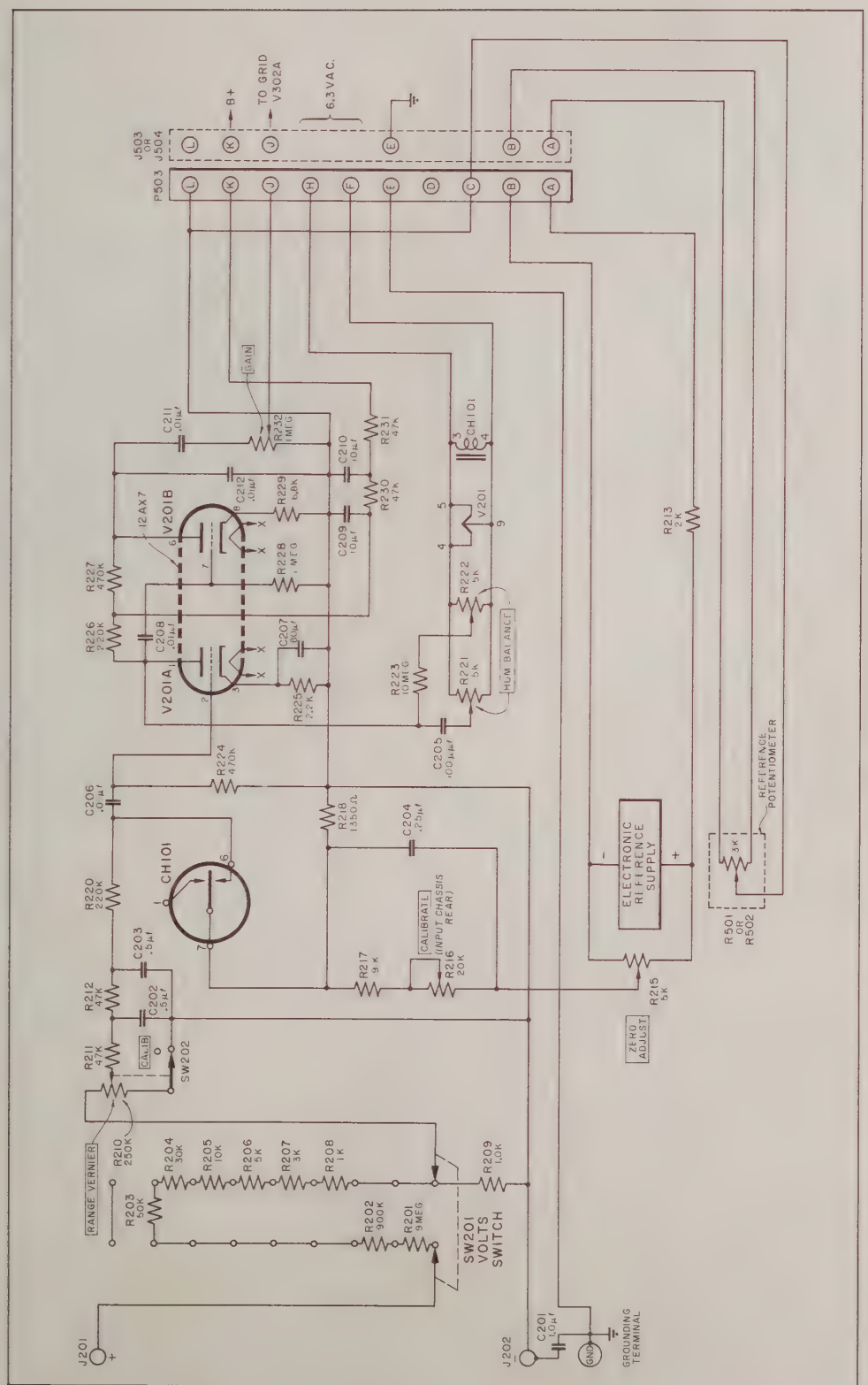


Figure 2-9: Type B-22 Input Chassis Schematic

2.6.2 DESCRIPTION OF CIRCUIT

The Type B-22 Input Chassis schematic is shown in Figure 2-9. The input network of the Type B-22 contains an adjustable attenuator circuit and associated switch. The attenuator or VOLTS switch, SW201, selects the recording range and is calibrated in nine full-scale signal amplitudes. In the one-volt range, a one-volt input signal will produce full-span pen deflection, etc.

An important feature of the Type B-22 Input Chassis is the RANGE VERNIER, R210. This control provides attenuation additional to that of the attenuator switch, SW201. In order to obtain full-span pen deflection for the indicated full scale ranges of the attenuator or VOLTS switch, the RANGE VERNIER must be in the CALIB. position, which removes it from the circuit. The RANGE VERNIER allows a continuous span adjustment from approximately 10 mv to the maximum value of the selected attenuator switch range setting, and spans up to 500v in the 100-v attenuator switch range.

The input impedance of the Type B-22 Input chassis in the 10-mv range of the attenuator switch, with the range vernier in CALIB., is greater than 0.5 megohm off null, approaching infinity at null. At other settings of the attenuator switch, the measured source will be loaded with the impedance of the divider circuit, whether on or off null. See Figure 2-10.

2.6.3 SPECIAL OPERATING NOTES

To use the RANGE VERNIER and attenuator switch, proceed as follows:

a) Set the attenuator or VOLTS switch to the nearest span range below the voltage of the signal to be measured, that is, to measure a *nine-volt signal* set the attenuator switch in the *one-volt* position.

b) Set the RANGE VERNIER with the pointer on the knob pointing straight up.

c) Apply the full-scale signal to be measured, adjusting the RANGE VERNIER for full-span-pen deflection. The recorder is now calibrated to give full-span deflection for the selected voltage.

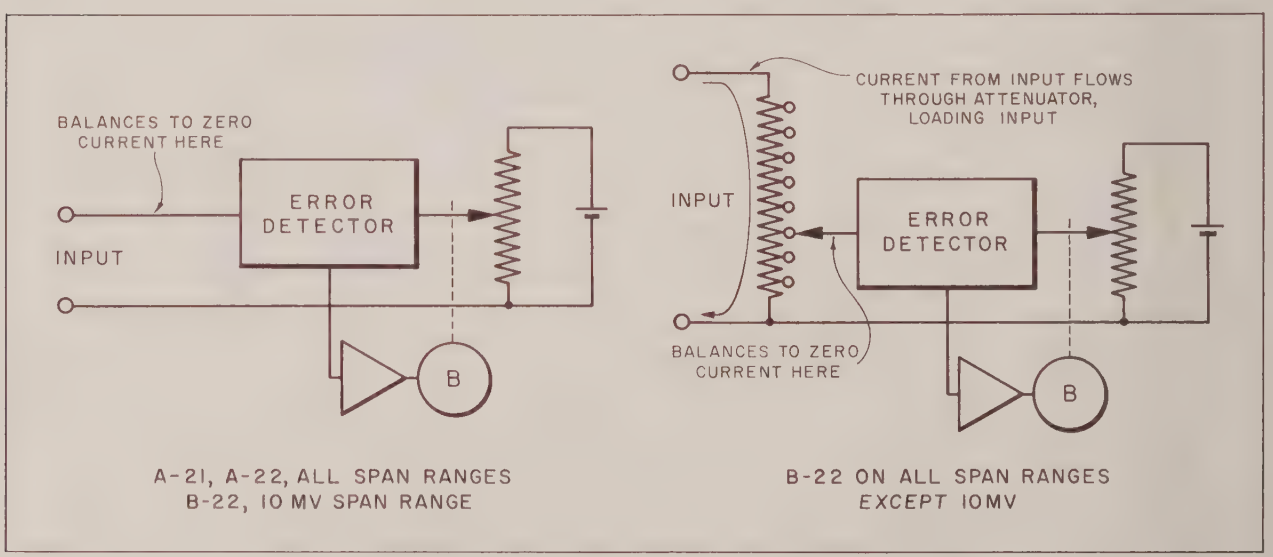


Figure 2-10: Equivalent Input Circuits—B-22, A-21 and A-22

2.7 TYPE T-22 THERMOCOUPLE INPUT CHASSIS

The Type T-22 Thermocouple Input Chassis is a modular, plug-in unit which permits the Model G-22 Dual Channel Recorder to be used in temperature recording applications. The T-22 provides suitable conditioning and pre-amplification of signals generated by the various thermocouple types which may be used with it. Because the temperature-responsive voltage generated by a thermocouple is proportional to the temperature difference between the measuring junction and the reference junction, variations in temperature at the reference junction will introduce undesired voltage variations in the voltage output of the thermocouple. The T-22 Input Chassis offers a patented method of accurate and automatic reference-junction temperature compensation. Temperatures may be recorded within 1% of span for ambient changes at the reference junction over the range of 0°C to 40°C, the recommended operating ambient of the G-22 Recorder. The Type T-22 Input Chassis is fully compatible electrically and physically with the main recorder assembly.

Most thermocouple types may be used with the T-22 Input Chassis. Changes of temperature range or thermocouple type require only a change of the Range Element, chart paper, and recorder scale. These are available in calibrations for the temperature ranges listed in Section 2.7.2. Range Elements contain resistor networks for use in various locations of the T-22 Input Chassis circuit to adjust the circuit for thermocouple output-voltage slope and temperature ranges. They are housed in tubular containers terminated in nine-prong miniature plugs, and are readily interchangeable. In addition to the standard Range Elements listed in Section 2.7.2, special range elements, chart paper, and scales can be supplied on order.

2.7.1 T-22 SPECIFICATIONS

LIMIT OF ERROR	1% of span (using specified chart paper)
RANGE OF AUTOMATIC REFERENCE-JUNCTION COMPENSATION	0° C to 40° C (ambient operating range of G-22 Recorder)
TEMPERATURE RANGES	Ranges provide continuous coverage from −200° C to +1500° C, or from −150° F to +2750° F. See Section 2.7.2 for details of available temperature ranges, appropriate range elements, chart paper, and scales. Special temperature ranges with appropriate range elements, chart paper, and scales are available at extra cost on order.
TUBE COMPLEMENT	1 – 12AX7

RANGE ELEMENT CALIBRATION VOLTAGE CHART

Range Element	*Full Span Calibration Voltage in Millivolts*	
	From 32° F	From 0° C
01	11.03	10.78
02	17.18	16.83
03	21.79	21.85
04	32.72	33.11
05	56.64	57.70
06	49.05	48.89
07	5.28	5.23
08	2.11	2.04
09	5.51	5.27
10	17.36	17.49

2.7.2 RANGE ELEMENTS, CHART PAPER TYPES, RECORDER SCALES

*Fahrenheit Calibration**		*Range Element*	*Chart Type*	*Scale*
0° to 400° F	(I-C type J)	01	101A	101-201
0° to 600° F	(I-C type J)	02	102A	102-202
0° to 750° F	(I-C type J)	03	103A	103-203
0° to 1100° F	(I-C type J)	04	104A	104-204
0° to 1800° F	(I-C type J)	05	105A	105-205
0° to 2200° F	(C-A type K)	06	106A	106-206
−150° to +250° F	(C-C type T)	07	107A	107-207
30° to 220° F	(I-C type J)	09	109A	109-209
30° to 2750° F	(P-PR type R)	10	110A	110-210

Centigrade Calibration		*Range Element*	*Chart Type*	*Scale*
−20° to +200° C	(I-C type J)	01	201A	101-201
−20° to +300° C	(I-C type J)	02	202A	102-202
−20° to +400° C	(I-C type J)	03	203A	103-203
−20° to +600° C	(I-C type J)	04	204A	104-204
−20° to +1000° C	(I-C type J)	05	205A	105-205
−20° to +1200° C	(C-A type K)	06	206A	106-206
−100° to +120° C	(C-C type T)	07	207A	107-207
−200° to +50° C	(C-C type T)	08**	208A	208
0° to +100° C	(I-C type J)	09	209A	109-209
0° to +1500° C	(P-PR type R)	10	210A	110-210

* I-C—Iron-Constantan
C-A—Chromel-Alumel
C-C—Copper-Constantan
P-PR—Platinum-Platinum 13% Rhodium

** Element 08, chart, and scale are available in centigrade calibration only, but range element covers the −325° to +125° F range.

2.7.3 DESCRIPTION OF CIRCUIT

Refer to Figure 2-11, the T-22 Input Chassis schematic. A temperature-proportional voltage from the thermocouple is applied to the input chassis across J201 and J202 and appears at the chopper contact, pin 6. Thermocouple output voltage is compared to a precision reference voltage adjusted by the balancing potentiometer, R501/502. This voltage is derived from a precise electronic reference voltage supply. (For a description of this supply, refer to Section 2.5.1.) Comparison of the two voltages takes place across resistor R404. When the two voltages are unequal, a square-wave voltage of chopper frequency, having an amplitude proportional to the difference of the thermocouple output voltage and the voltage at the balancing potentiometer slider, appears across R404 where it is applied to the grid of V201A. It is subsequently amplified and applied to the servo motor control winding, energizing the servo motor. The servo motor then rotates the balancing potentiometer slider until the voltage across R404 is zero.

C202 and R206 form a lead network which damps the recorder. R401, R402, R403, and R404 are contained in the Range Element plug-in unit. R404 determines the temperature range which will create full-span pen deflection. R218 is a temperature-sensitive resistor at the termocouple reference junction. This resistor compensates for thermocouple reference junction ambient temperature variations.

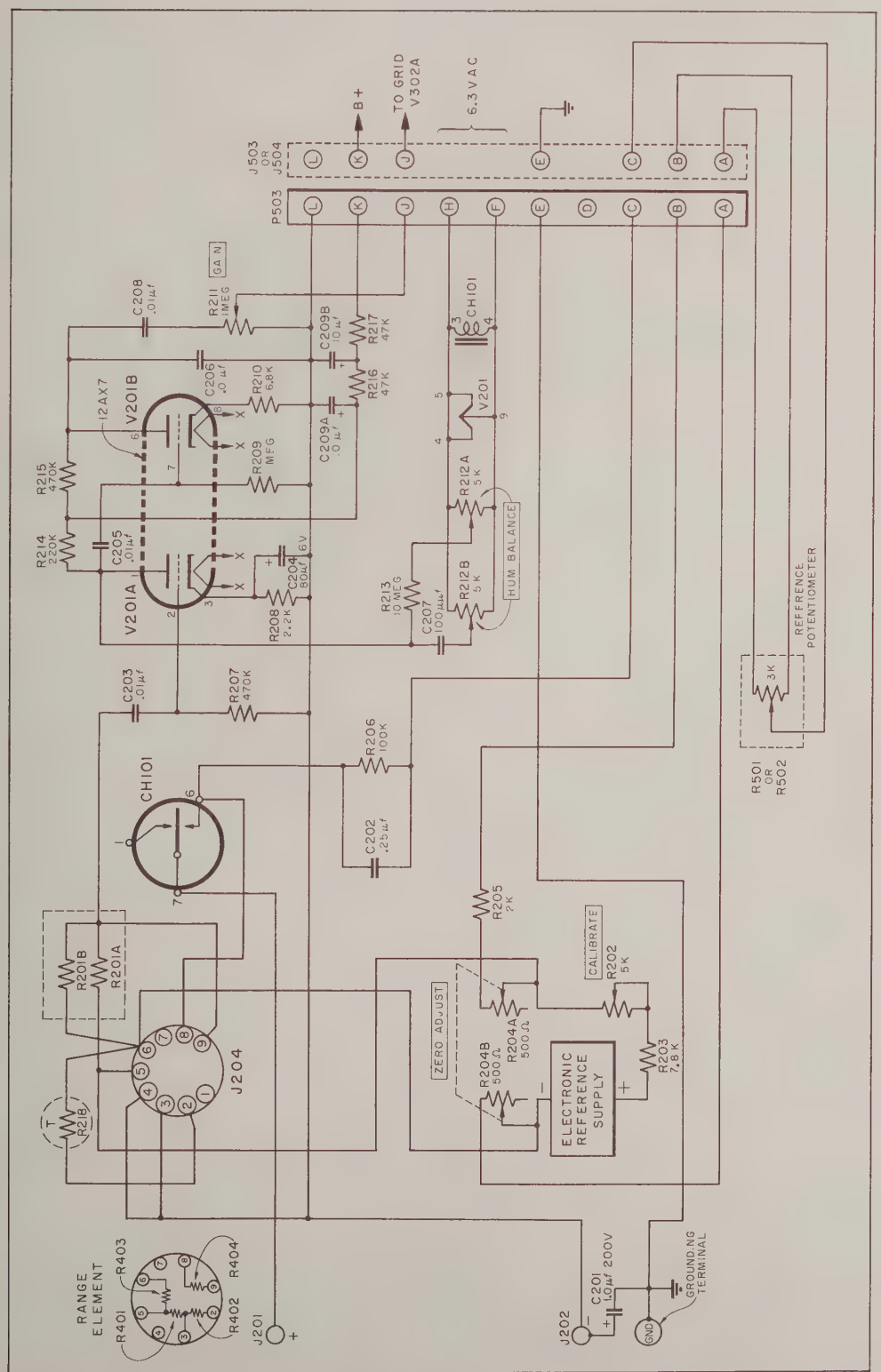


Figure 2-11: Type T-22 Input Chassis Schematic

2.7.4 CONTROLS AND ADJUSTMENTS

The T-22 Input Chassis contains the following controls and adjustments:

CALIBRATE control

CALIBRATE control, R202, is shown in Figure 2-11, the T-22 Input Chassis schematic. This resistor is in series with the electronic reference voltage supply, thereby controlling its output voltage, hence the span of the recorder.

ZERO ADJ control

ZERO ADJ control consists of dual variable resistor R204. The ZERO ADJ control is used to position the recorder pen at a selected reference point located at the low end of the recorded temperature range, for example (but not necessarily), 0° C or 32° F.

GAIN control

GAIN control, R211, controls the signal output to the servo amplifier. Readjustment of this control may be necessary if the input chassis tube is changed.

HUM BALANCE controls

HUM BALANCE controls, R212A and R212B, (location shown in Figure 4-3 for the A-21 Input Chassis is the same for the T-22) provide amplitude and phase adjustment of a hum bucking signal derived from the a-c filament for best hum cancellation.

2.7.5 OPERATING INSTRUCTIONS

a) Plug T-22 Input Chassis into G-22 Recorder. Insert proper Range Element, chart, and recorder scale for thermocouple used and temperature range to be recorded. Refer to Section 2.7.2 above.

b) With scale fastening screws loosened, position scale laterally so that recorder pen and pointer align with corresponding chart and scale calibrations, respectively. Fasten scale mounting screws.

c) Connect G-22 Recorder to power line. Turn HIGH–LOW–STDBY–OFF switch to STDBY.

d) Connect thermocouple to T-22 Input Chassis at J201 and J202 input terminals observing correct polarity. To record, place the HIGH–LOW–STDBY–OFF switch in HIGH or LOW as required. NOTE: Positions of T-22 Input Chassis in the recorder cannot be interchanged without recalibration.

2.7.6 CALIBRATION

The T-22 Input Chassis has been accurately calibrated at the factory. The unit does not require recalibration when Range Elements and thermocouples are exchanged, nor do any of its controls require readjustment. However, if the T-22 has been in operation for considerable time and recordings of high reliability are required, a calibration check may be desirable due to aging of components. Check performance before attempting to adjust any of the controls. As a rule, it is best not to tamper with the adjustments of this input chassis unless calibration and adjustment are absolutely necessary.

To duplicate factory calibration accuracy in the field requires careful execution of the following steps:

a) Prepare an ice-water bath in a thermos or Dewar container. Use distilled water and ice made from distilled water, otherwise the temperature of the bath may not be accurate enough for calibration purposes. The ice must be melting.

b) Proceed with the steps of Section 2.7.5.

c) With the HIGH–LOW–STDBY–OFF switch in HIGH, immerse thermocouple measuring junction in the ice-water bath.

d) After immersion of the thermocouple measuring junction for approximately five minutes, adjust the ZERO ADJ control until the recording pen rests at the 0°C or 32° F point of the chart. (For suppressed zero operation, see Section 2.7.6.1, below.)

e) Refer to Figure 2-12, Calibration Voltage Source. Break the positive thermocouple lead, and fasten the part attached to the measuring junction to the positive terminal of the calibration voltage source, and the remaining part from the negative terminal of the calibration voltage source to the positive terminal of the T-22 Input Chassis. Connect the negative thermocouple lead to the negative terminal of the T-22 Input Chassis. NOTE: Make sure that the two terminals of the calibration voltage source are at the same temperature. When using iron-constantan thermocouples, the iron thermocouple lead (positive) may be broken and attached to the calibration voltage source through two ten-inch lengths of copper wire, rather than attaching it directly as above. Keep the junction points with the two connecting wires from contacting any surface. In this way the junction points will remain approximately at room temperature. The exact temperature is unimportant, so long as it is the same at both points.

f) Adjust the output of the calibration voltage source until full-span pen deflection occurs. Refer to the Range Element Calibration Voltage

Chart, page 2-11. The voltage across the T-22 input terminals should be within 1% of the voltages listed, as applicable. If not, adjust the CALIBRATION control and the calibration voltage source until full-span pen deflection occurs at the specified voltage for the range element being used.

g) Strap the calibration voltage source terminals together and repeat step (d) above. NOTE: It is possible that minor difficulties may be experienced when attempting to use a new T-22 Input Chassis with a G-22 Recorder that has been in use for some time. In such cases, check the list of possible causes below. The trouble can invariably be eliminated by so doing. Do not attempt to recalibrate the input chassis as a first step toward locating and eliminating troubles. Recalibration should always be a final step after a thorough check of operation indicates that it is necessary. If either full-scale or zero calibration cannot be achieved, check the following:
   1. Chart paper (for correct type)
   2. Thermocouple type
   3. Thermocouple lead polarity
   4. Range element
   5. Calibration voltage
   6. Balancing potentiometer phasing (see Section 4.3.4)
   7. Gain (for this adjustment see Section 4.2.4. This section covers gain adjustment for the A-21 Input Chassis, but is fully applicable to the T-22, including the gain control location as shown in Figure 4-3.)

h) Secure all adjustment locking nuts.

2.7.6.1 SUPPRESSED ZERO CALIBRATION

In suppressed-zero operation, the lower scale limit, or right-hand margin of the chart, is calibrated at some point above 0° C or 32° F. Suppressed-zero charts and range elements are often supplied on order. These steps are also applicable to any recording application in which 0° C or 32° F is off the scale, whether above the upper scale limit or below the lower scale limit.

a) Perform steps a, b, and c of Section 2.7.6. An ice-water bath is used to provide an accurate reference temperature.

b) Attach the thermocouple positive and negative leads as outlined in step (e) of Section 2.7.6 to a suitable calibration voltage source. Adjust the output of this source so that the pen rests at the right-hand margin of the chart (without having made any adjustments to the T-22 Input Chassis itself).

c) Refer to United States Department of Commerce NBS Circular 561, entitled "Reference Tables for Thermocouples", issued April 27, 1955. This document contains tables of output voltage versus temperature and other data for generally used thermocouples types in the United States. Refer to the section applicable to the particular thermocouple being used. Note the listed thermocouple output voltage corresponding to the lower scale temperature. Supply the proper voltage across the T-22 Input Chassis input terminals, and adjust the calibration voltage source until this voltage equals the listed voltage.

d) Adjust the ZERO ADJ control until the pen rests at the lower-scale temperature mark.

e) Repeat the same procedure for establishing the upper scale maximum as is covered in step (c) above, adjusting the output voltage of the calibration voltage source so that the voltage across the T-22 input terminals equals the listed thermocouple output voltage for the upper scale temperature.

f) Adjust the CALIBRATION control until the pen rests at the correct upper scale limit.

g) Secure all adjustment locking nuts.

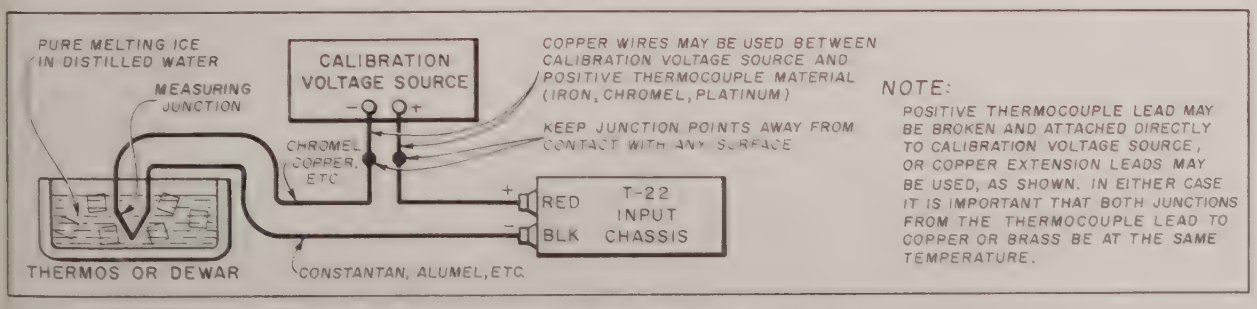

PURE MELTING ICE IN DISTILLED WATER
MEASURING JUNCTION
CALIBRATION VOLTAGE SOURCE
−
+
COPPER WIRES MAY BE USED BETWEEN CALIBRATION VOLTAGE SOURCE AND POSITIVE THERMOCOUPLE MATERIAL (IRON, CHROMEL, PLATINUM)
KEEP JUNCTION POINTS AWAY FROM CONTACT WITH ANY SURFACE
CHROMEL COPPER, ETC
+
RED
T-22 INPUT CHASSIS
−
BLK
THERMOS OR DEWAR
CONSTANTAN, ALUMEL, ETC
NOTE:
POSITIVE THERMOCOUPLE LEAD MAY BE BROKEN AND ATTACHED DIRECTLY TO CALIBRATION VOLTAGE SOURCE, OR COPPER EXTENSION LEADS MAY BE USED, AS SHOWN. IN EITHER CASE IT IS IMPORTANT THAT BOTH JUNCTIONS FROM THE THERMOCOUPLE LEAD TO COPPER OR BRASS BE AT THE SAME TEMPERATURE.

Figure 2-12: Calibration Voltage Source

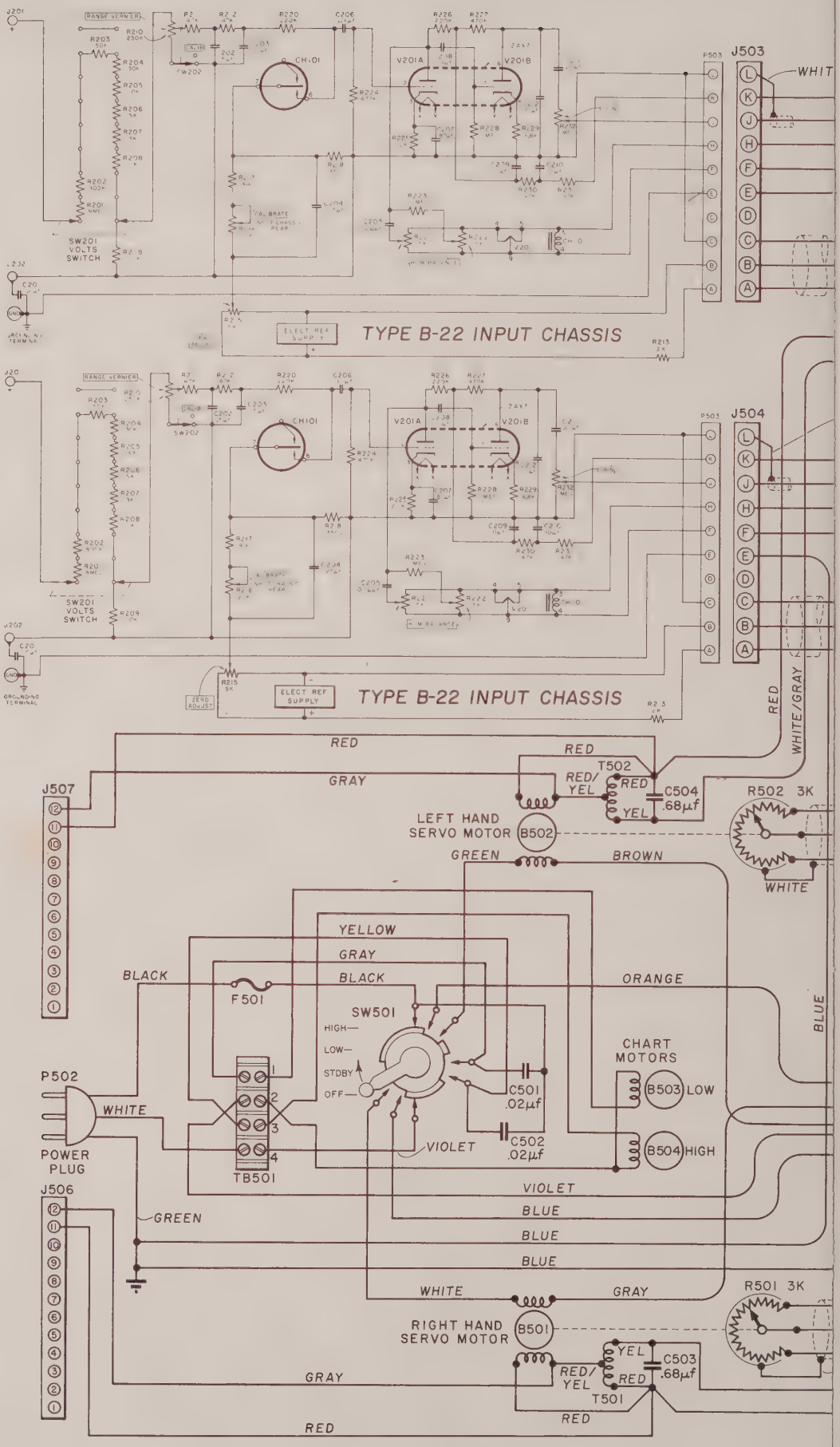
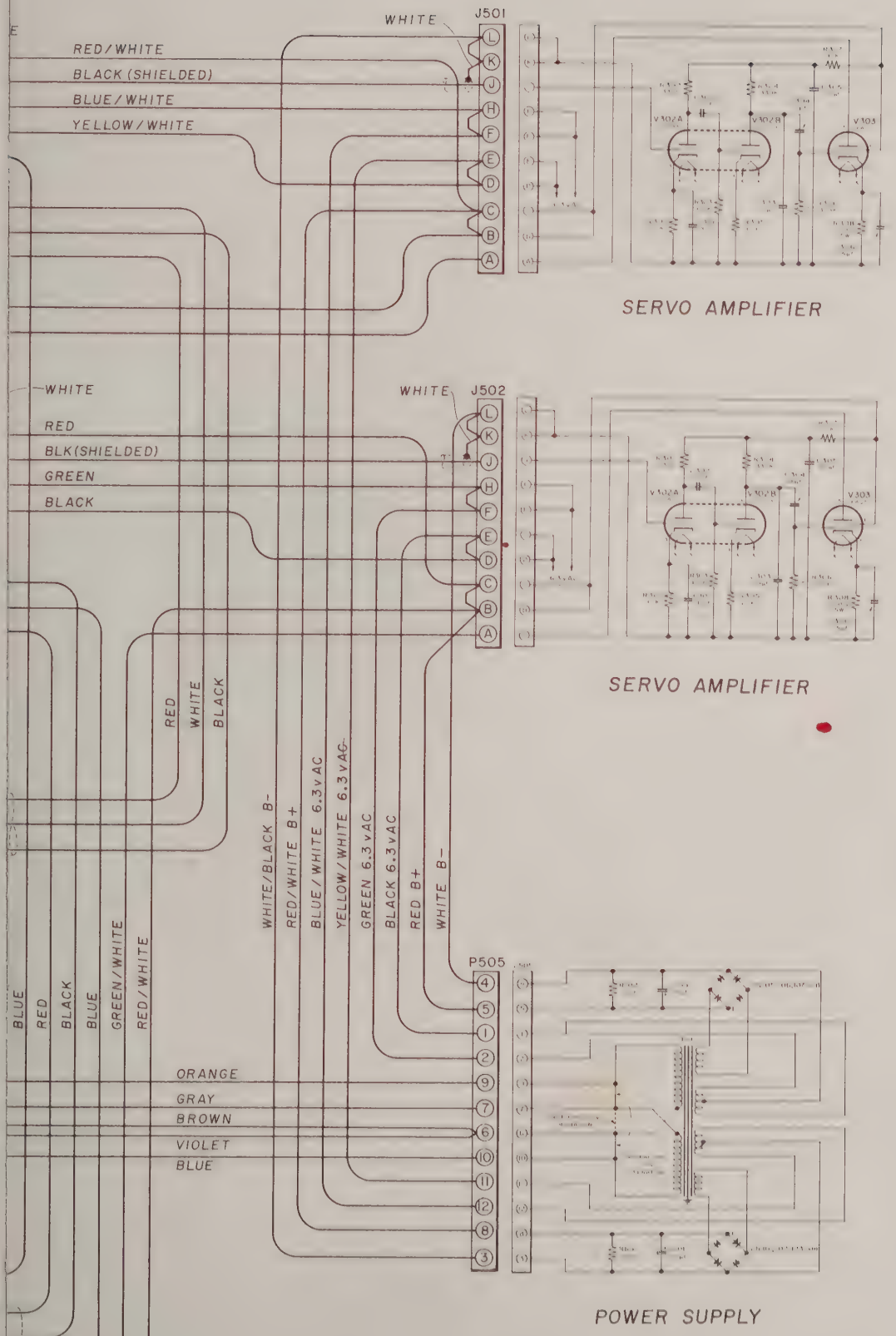


FIGURE 2-15: MAIN RECOR



DER ASSEMBLY SCHEMATIC

operating instructions

3.0 SETUP AND OPERATION

3.1 GENERAL

Before attempting to install or operate the Model G-22 Recorder, please read the warranty information opposite the inside rear cover of this manual, and inspect the instrument carefully. It has been adjusted, calibrated, and thoroughly tested prior to shipment. Except for ink and chart paper, it is ready to operate.

WARNING:
GROUND RECORDER BEFORE OPERATING

3.2 POWER REQUIREMENTS

The Model G-22 Recorder operates from the 110-v 60-cps single-phase line, or, when so specified, the 220-v line. A ground conductor is contained in the power cord, which terminates in a three-prong plug, the tubular pin being the ground connection. If the wall receptacle does not have a ground connection, a three-to-two terminal adapter must be used. For safety and for reduction of hum pickup the adapter ground lead should be well grounded.

3.3 SIGNAL, AND SIGNAL SOURCE REQUIREMENTS

Changes in the measured signal should not exceed the Model G-22 Recorder's one-second full-span balancing time. No damage to the recorder will result from fast-changing signals, but the recording will not be an accurate representation. Source impedance can range from a fraction of an ohm to the maximum impedances stated in the specifications. Source impedances which exceed maximum limits will result in greater dead band, particularly in the range of minimum span. Except when in the 10-mv span range, the Type B-22 Input Chassis will load the signal source with the impedance of its input voltage dividers. See Section 2.6.2.

Although recorder signal inputs may float above ground, they are not balanced. The Type A-21 Input Chassis schematic, Section 2, Figure 2-7, for example, shows C203 connected between signal ground and chassis ground. The input filter network is connected between J201 and J202. J202 can be connected to the chassis *if the signal source is not floating.* Correct polarity should be observed to see that J201 is not grounded.

3.3.1 SIGNAL CONNECTIONS

Because the Model G-22 Recorder converts the d-c input signal to an a-c signal of line frequency, any noise of line frequency appearing across signal inputs J201 and J202 will cause errors. Such noise frequently results from coupling to the power line. Two types of coupling can occur. With high source impedance, coupling may be electrostatic. Shielded cable should be used between the recorder and the signal source to eliminate this type of coupling. The shield should be attached to the recorder chassis ground only, and the two internal leads connected to J201 and J202. Attaching the shield to both the recorder and measured-source chassis grounds may cause ground loops.

With low source impedances coupling is mainly inductive. Shielding is not required, but the two leads from the measured source to the recorder should be twisted together and kept as short as possible.

When operating the recorder with input signals biased above ground potential, a d-c offset may occur in very humid conditions. This is caused by insulation leakage combined with the high gain of the servo amplifier. These effects may be offset by the ZERO ADJUST control.

Signal voltages greater than those specified can be applied through suitable voltage dividers. Care should be observed in calculating scale factors.

3.4 INSTALLING PENS

To install pens, refer to Figures 3-1 and 2-4.

a) Remove the Recorder from its case by loosening the two captive screws, one on each side of the assembly as shown in Figure 3-1.
b) Fill ink reservoirs and secure in position with the springs provided, as shown in Figure 2-4.
c) Install the red pen on the rear pen bearing, and the blue pen on the front. Pens snap onto the pen bearings using clips. See that the lower holes in the grip rings through which the pen dial cords are fastened line up with the dial cord pulleys at the chart edges. If pens are installed so the grip rings are rotated too high or too low, improper pen contact with the chart will occur.
d) Attach capillary feed tubes. When facing the recorder the feed tube from the left-hand reservoir should be connected to the red pen. This tube should be placed between the two feed-tube guide rods as shown in Figure 2-4. The other feed tube should be placed above the

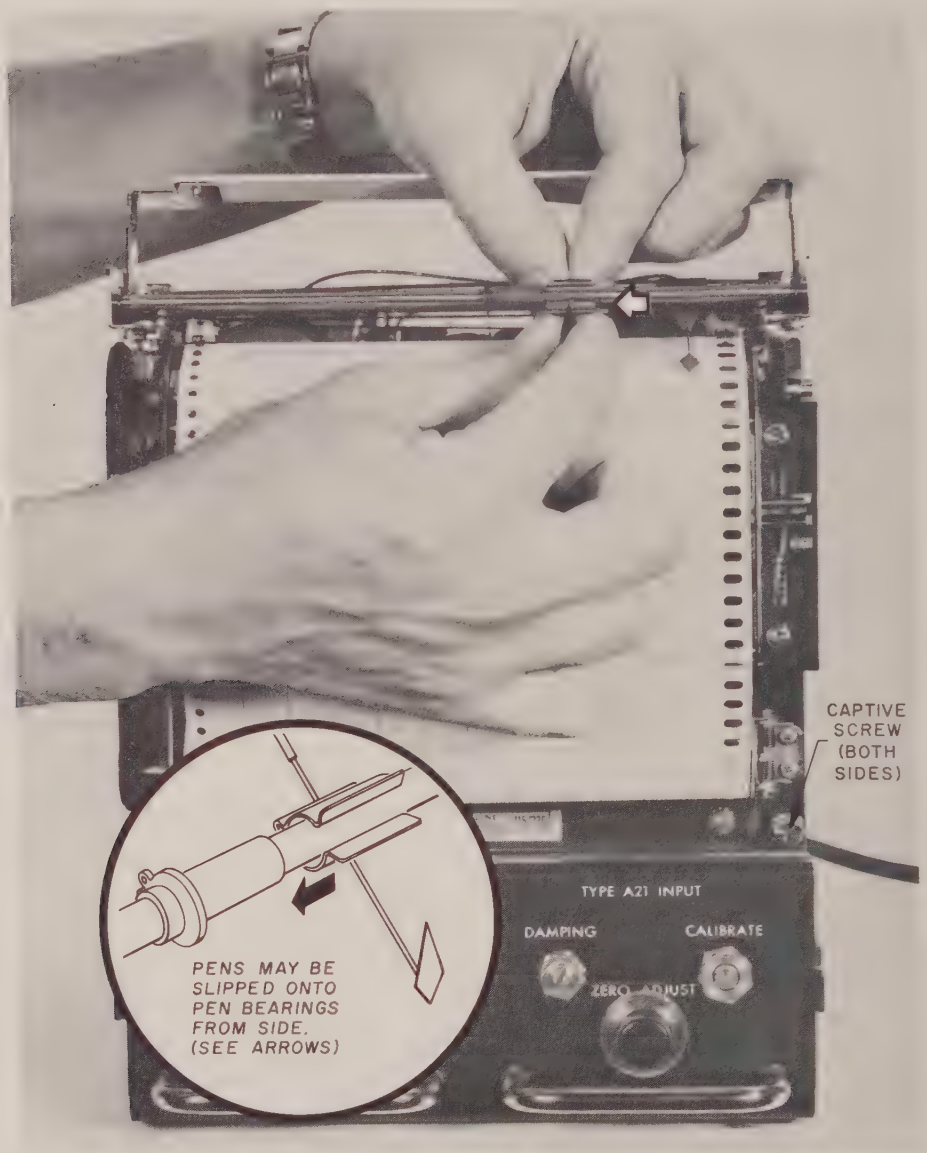


Figure 3-1: Details of Pen Installation Procedure

guide rods. The feed tubes should be slipped over the rear of the pen tubes for a distance of approximately 1/8 inch.

e) To prime the pens, refer to Figure 3-3. Using the pen primer as shown, slip the end of the pen tube into the primer and suck ink through the feed tube. After initial pen installation and reservoir filling, this step can be accomplished without removing the G-22 Recorder from its case. If the recorder is to stand idle for any period of time, the pen primer should be used to purge the pens and feed tubes of ink, reducing the likelihood of clogging.

f) Adjust the height of the ink reservoir bottles for proper ink flow. The correct height is determined by the writing rate. The height will be greater for high recording rates than for low rates. When the ink reservoir bottles are too high, excessive ink may flow out onto the chart, when too low, the trace will be thin or intermittent.

g) Re-install the Recorder in its case.

3.5 INSTALLING THE CHART

To install the chart, proceed as follows.

a) Note the callout nomenclature of Figure 3-2. Compare the recorder with Figure 3-2.

b) Lift scale and unsnap platen from spacer rods.

c) Unwrap one end of the chart roll. Fold chart corners as shown in Figure 3-2. With chart recording surface toward rear of recorder, thread chart through guide slot until it engages the drive sprockets on both sides.

d) Place the HIGH - N - LOW gear shifter in "N" position.

e) Advance chart by hand, and replace platen.

f) Insert chart re-roll tube at bottom, with slots toward left. Engage slots with teeth of re-roll tube take-up pulley.

g) Unroll a length of chart paper sufficient to reach the re-roll tube. Tape as shown in Figure 3-2, using masking tape.

h) Wind several turns of chart paper on the re-roll tube by rotating the chart take-up drive pulley. Take up any remaining slack in the chart paper so that it is flat against the platen.

3.6 REVIEW OF CONTROL LOCATION AND FUNCTIONS

The following controls are located on the main recorder assembly:

LOW - N - HIGH gear shifter—this control provides a four-to-one chart speed reduction between HIGH and LOW. N is a neutral position.

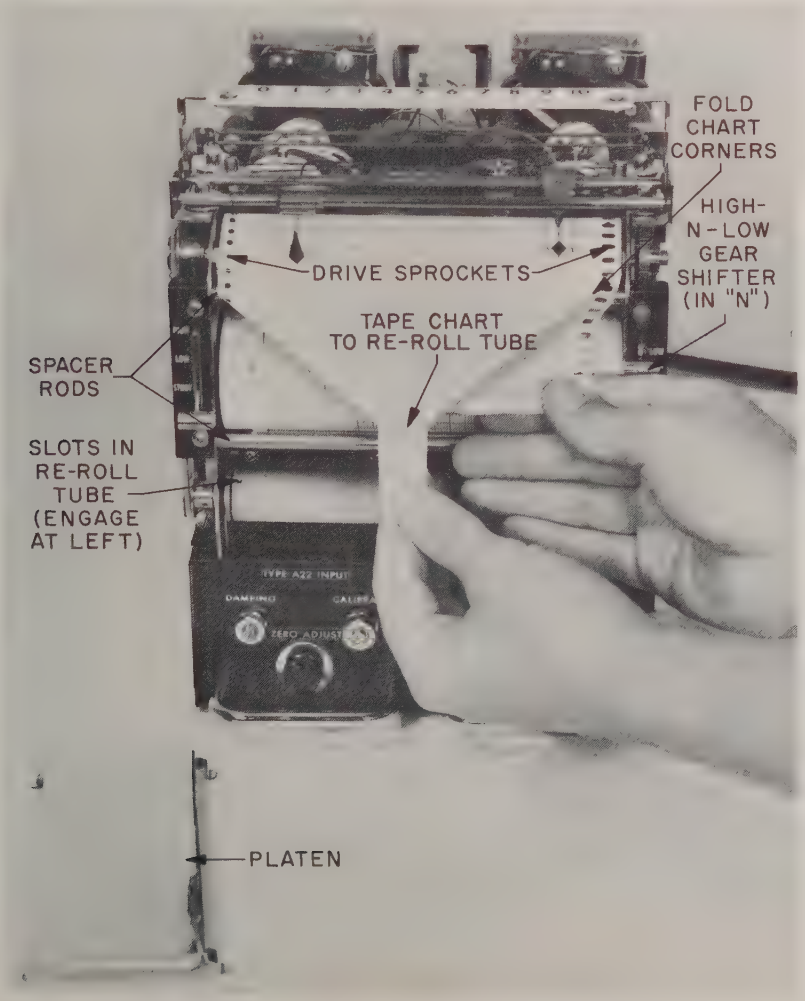


Figure 3-2: Chart Installation Procedure

HIGH - LOW- STDBY - OFF switch—this switch controls recorder power, and when the recorder is supplied with two chart drive motors, selects the low- or high-speed motor. In STDBY amplifiers are on and only the control winding of the servo motor is energized. In LOW and HIGH the low- and high-speed chart drive motors, respectively, are operative, and the line winding of the servo motor is energized. If only one chart drive motor is supplied, it operates in HIGH only.

The following controls are located on the input chassis. See Section 4 for their adjustment.

DAMPING—adjusts the damping factor.

ZERO ADJUST—adjusts the zero-signal pen position to any desired point on chart.

CALIBRATE—a fine span adjustment.

GAIN—servo amplifier gain adjustment

HUM-BALANCE adjustment

SPAN adjustment

3.7 DETAILED OPERATING INSTRUCTIONS

a) After filling the reservoir with ink and installing the pens and chart paper, plug the recorder into the ac line, observing considerations of Section 3.2.

b) Place the HIGH - LOW - STDBY - OFF switch in HIGH or LOW, and the LOW - N - HIGH gear shifter in N . Allow recorder amplifiers to warm up for one minute.

c) Short the signal input terminals together.

d) Adjust the ZERO ADJUST control for the desired zero-signal pen position on chart.

e) Remove shorting connection across signal inputs and connect an appropriate signal source, observing considerations of Sections 3.3, and 3.3.1.

f) Place HIGH - LOW - STDBY - OFF switch and LOW - N - HIGH gear shifter in desired position.

g) The Recorder is now ready to record.

Figure 3-3: Pen Priming

service and maintenance

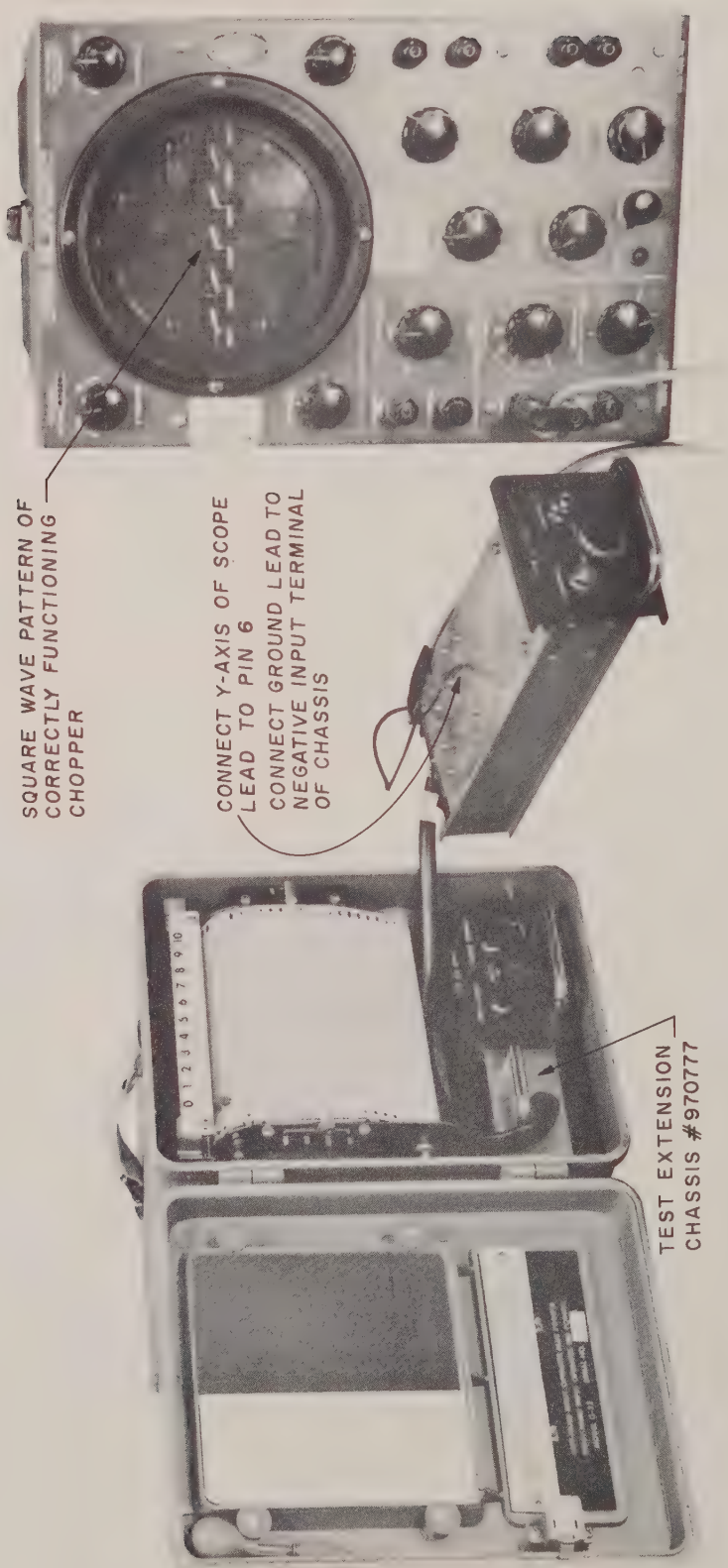

SQUARE WAVE PATTERN OF CORRECTLY FUNCTIONING CHOPPER
CONNECT Y-AXIS OF SCOPE LEAD TO PIN 6
CONNECT GROUND LEAD TO NEGATIVE INPUT TERMINAL OF CHASSIS
TEST EXTENSION CHASSIS #970777

Figure 4-1: Chopper Test Procedure

4.0 SERVICE AND MAINTENANCE

4.1 GENERAL

Before attempting service, adjustments, and maintenance of *new equipment*, please read the warranty information opposite the inside rear cover of this manual.

The instructions which follow apply to Type A-21, A-22, and B-22 input chassis and the main recorder assembly. When other input chassis are involved, the description of operation for the particular input chassis should be consulted in Section 2 for service and maintenance information.

4.2 PERFORMANCE CHECKS AND ADJUSTMENT OF ELECTRONIC UNITS

The modular construction of the Model G-22 Recorder offers many service, maintenance, and trouble-shooting shortcuts because major subassemblies may be checked by substitution. When one channel becomes inoperative, the input chassis, servo amplifier printed circuit board, tubes, reference cell, chopper, and power supply of the operative channel may be exchanged with those of the inoperative channel until the faulty subassembly is located.

4.2.1 MERCURY REFERENCE CELL

A mercury cell is used in the Type A-21 input chassis as the reference voltage source. To eliminate surface-charge effects and thus allow the recorder to be used with full accuracy immediately upon warmup, the cell is allowed to discharge continuously whether the recorder is on or off. Once the cell is installed, its life is about four months, after which its voltage drops to an unusable value. Low reference cell voltage will cause a decrease in span.

To replace the cell, unsnap it from its holder in the input chassis. Replace with Varian part number 74-101 550, making sure that the positive terminal (marked on cell) faces the rear of the chassis, or the red lead on the cell holder.

4.2.2 ELECTRONIC REFERENCE VOLTAGE SUPPLY

Figure 2-8, Section 2, is the electronic reference voltage supply schematic. The operation of this unit may be checked as follows:

a) Remove the two fastening screws which secure the unit to the input chassis, unplug the connector, and remove the unit from the input chassis.
b) Place a 2.5k-ohm resistor across terminals 1 and 7 of the connector plug.
c) Supply 6.3 vac to terminals 3 and 4 of the connector plug.
d) Measure the voltage across terminals 1 and 7. This should be within ±10% of 8 vdc. Incorrect operation will result in wide deviation from this value.

If the electronic reference voltage supply is faulty, it should be replaced. Do not attempt to adjust R404, or to replace components.

4.2.3 CHOPPER

If the chopper is suspected of malfunctioning, it can be checked as follows:

a) First remove both input chassis from recorder and reverse chassis position. If malfunction switches to other channel, refer to Figure 4-1, remove input chassis containing suspected chopper, and connect it to recorder using test extension chassis 970777.
b) With input chassis thus exposed, locate terminal 6 on the chopper socket. Connect the positive terminal of an oscilloscope Y-axis input to terminal 6 of the chopper socket. Connect the negative terminal to the negative recorder input terminal.
c) With the recorder plugged into the a-c line, and with the HIGH - LOW - STDBY - OFF switch in STDBY, apply a full-span input voltage to the recorder, and set the scope Y axis gain to the correct range for this signal.
d) If ringing or an incorrect duty cycle are shown, discard the chopper, and replace with Varian part number 901335. While the test arrangement is set up, test the new chopper. A clean square wave should be produced, and a 50% duty cycle indicated (equal on and off times).
e) If a test extension chassis is not available, the alternative chopper test method detailed in Figure 4-2 may be used, or the bottom of the recorder can be removed for access to the input chassis.

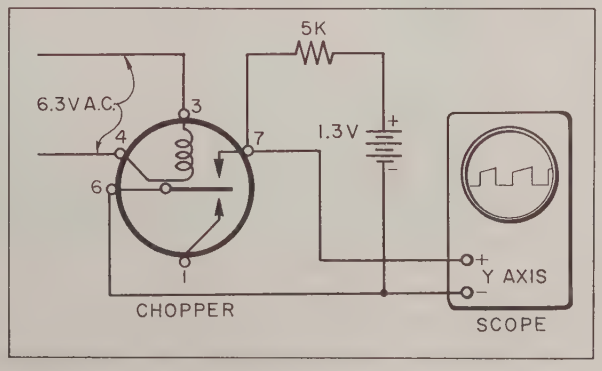


Figure 4-2: Alternative Chopper Test Circuit

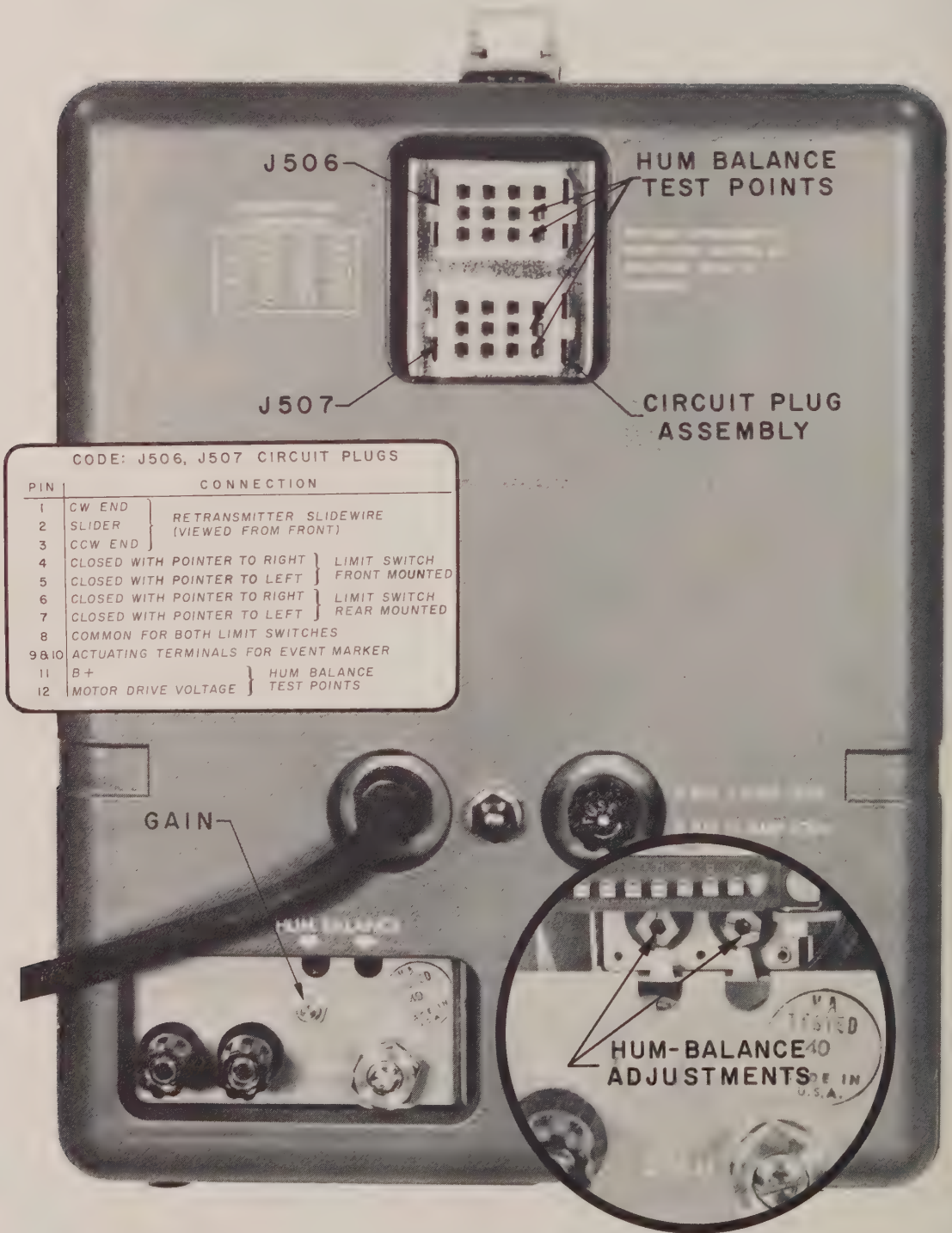


Figure 4-3: Location of Servo Amplifier Gain Control in all Input Chassis

4.2.4 SERVO AMPLIFIER GAIN

Figure 4-3 shows the location of the servo amplifier gain control, R-218 in the Type A-21 Input Chassis, schematic Figure 2-7, Section 2. When tubes age, or when span is readjusted (Section 4.2.9), gain adjustment is usually necessary. Rotate the gain control clockwise until oscillation or "jitter" occurs in the servo motor (visible at the pens), and then back off until oscillation just stops.

4.2.5 DAMPING

The three damping conditions are: over-damping, under-damping, and critical damping. When the system is over-damped, the pen creeps into balance position. When under-damped, it overshoots balance position and oscillates briefly. When critically damped it approaches balance position and halts. Figure 4-4 illustrates representative traces.

Check damping as follows:

a) Check the mechanical damping of the servo motor as described in Section 4.3.5.
b) Short the signal input terminals together.
c) Adjust the HIGH - LOW - STDBY - OFF switch and the HIGH - N - LOW gear shifter to HIGH. (The usefulness of this step depends on the chart speeds supplied. If they are sufficiently high to provide a trace similar to that of Figure 4-4, then comparison of Figure 4-4 with the trace obtained will be helpful.)
d) Rotate damping control to extreme clockwise position.
e) Apply a suitable input signal to the recorder, and remove the shorting connection across the input terminals. Cycle the recorder by re-shorting input terminals several times. Adjust damping control until a pattern similar to Figure 4-4B is obtained. Alternately, when recorder is supplied for slow chart-speed operation and a trace such as Figure 4-4B cannot be obtained, observe pen action carefully and adjust damping until overshoot just disappears.

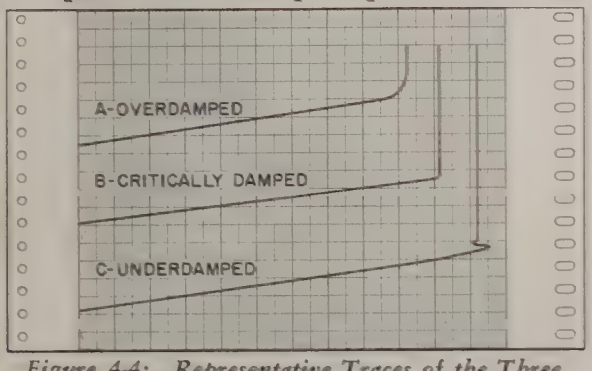


Figure 4-4: Representative Traces of the Three Damping Conditions

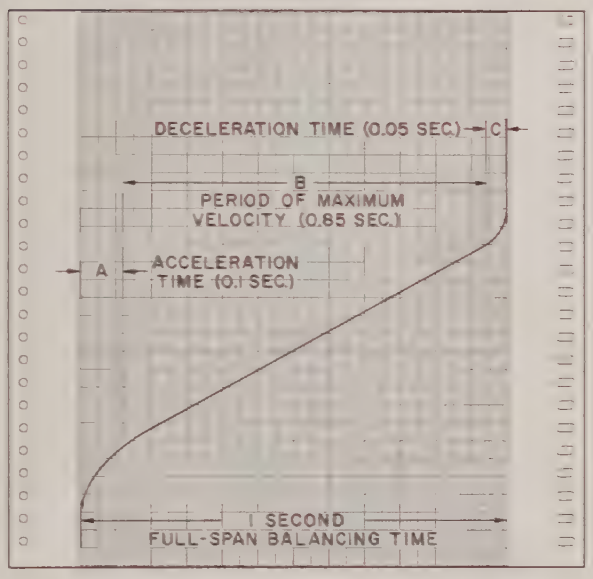


Figure 4-5: Representative Trace of Correct Balancing Time with a Full-Scale Step Input

4.2.6 BALANCING TIME

Figure 4-5 is a test trace produced by a full-scale input to the recorder. The trace consists of three segments. A, acceleration time, B, period of maximum velocity, and C, deceleration time. As indicated in Figure 4-5, acceleration time is less than 0.1 second, maximum velocity time approximately 0.8 second, and deceleration time 0.05 second. The recorder was adjusted for critical damping, i.e., fastest response with zero overshoot.

Check balancing time as follows:

a) Short the signal input terminals together.
b) Adjust the HIGH - LOW - STDBY - OFF and the HIGH - N - LOW gear shifter to HIGH. (The usefulness of this step depends on the chart speeds supplied. If they are sufficiently high to provide a trace similar to that of Figure 4-5, then comparison of Figure 4-5 with the trace obtained will be helpful.)
c) Rotate the ZERO ADJUST control suddenly to the extreme counter-clockwise position, then fully clockwise. Roughly note balancing time by checking against wrist watch, or inspect the recorded trace. If balancing time is excessive, or if chart speeds are sufficient to indicate a non-

linear trace, binding in the mechanical section is indicated. See Section 4.3.

4.2.7 CALIBRATION

Calibration of mercury-cell equipped recorders should be performed whenever precise recording is required because of the slight mercury-cell voltage decay with time. The following steps also apply to input chassis equipped with electronic reference voltage supplies. To calibrate either type of input chassis, proceed as follows:

a) Short the signal input terminals together.
b) Turn HIGH - LOW - STDBY - OFF switch to HIGH or LOW.
c) Adjust ZERO ADJUST control until pen rests at left-hand chart margin.
d) Remove shorting connection between input terminals.
e) Apply an accurate full-scale input signal to input terminals.
f) Rotate CALIBRATE control until the pen balances at right-hand chart margin.

4.2.7.1 CALIBRATION VOLTAGE SOURCE

Figure 4-6 is the schematic of a simple, accurate calibration voltage source. Resistance values should be within ±1%, and a *new* mercury cell, aged for approximately four hours in the circuit, should be used. Component values for various full scale voltages are contained in the chart.

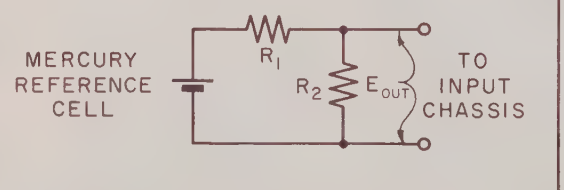


CHART OF COMPONENT VALUES

E_{OUT}	100 mv	50 mv	20 mv	10 mv
R_1	12.5K	13K	40K	40K
R_2	1K	500Ω	600Ω	300Ω

Figure 4-6 A Simple Calibration Voltage Source

4.2.8 ZERO ADJUST

The ZERO ADJUST control adjusts pen position to any desired point on chart for zero-signal input conditions.

4.2.9 SPAN ADJUST

Span of Types A-21 and A-22 Input Chassis is adjusted at the factory according to the purchaser's order specifications, for spans of 10 mv through 100 mv. The most important requirement in making an accurate span adjustment is an accurate input signal. The schematic of Figure 4-6 may be used.

To adjust span, proceed as follows:

a) Remove input chassis from recorder. For a span range of 10 mv to 20 mv, V-201=12AX7, for a span range of 20 mv to 50 mv V201=12AT7, and for a span range of 50 mv to 100 mv V201=12AU7. Install appropriate tube and replace input chassis.
b) Turn HIGH - LOW - STDBY - OFF switch to HIGH or LOW.
c) Short the signal input terminals together.
d) Turn span control approximately ¾ turn counterclockwise.
e) Adjust ZERO ADJUST control until pen rests at left-hand chart margin (viewed from front of recorder).
f) Remove connection from input terminals.
g) Apply an accurate full scale voltage.
h) Adjust span control until pen rests at right-hand chart margin (viewed from front of recorder).
i) Adjust the servo amplifier gain as outlined in Section 4.2.4.
j) Repeat steps (e) through (h), above.
k) Adjust servo amplifier gain, and lock span adjustment.

4.2.10 HUM BALANCE

The hum balance is factory adjusted and should not require readjustment until V201 is replaced. Figure 4-3 shows the hum-balance screwdriver adjustments and the hum balance test points, terminals 11 and 12 of the circuit plug assembly.

Adjust the hum balance as follows:

a) Remove the input chassis from the recorder and remove the mercury reference cell or unplug the electronic reference supply from the input chassis. (It will be necessary to remove the two screws which hold the electronic reference supply to the input chassis.) The reason for this step and (b) below is that dc in the system from the input terminals or the reference source will be converted to 60 cps by chopper action. Achieving minimum hum in this condition may result in nulling against a signal input, giving an erroneous reading.

b) Short the signal input terminals together.
c) Re-install input chassis and turn the HIGH - LOW - STDBY - OFF switch to HIGH or LOW.
d) Turn the servo amplifier gain control fully clockwise.
e) Using an a-c voltmeter, set the range to 100v and read the a-c voltage across terminals 11 and 12 of the circuit plug assembly for the channel concerned.
f) Adjust the a-c voltmeter to the voltage range which will provide a reading.
g) Using a non-metallic screwdriver (TV adjustment type) rotate the two hum-balance potentiometers until a minimum a-c reading is obtained. The two potentiometers act independently, hence the sequence of adjustment does not matter. The hum-balance reading should show a minimum a-c voltage of approximately 50 volts. It will be necessary to readjust servo amplifier gain as covered in Section 4.2.4.

4.2.11 DEADBAND

Check deadband as follows:

a) Remove the recorder from its case by loosening the two captive screws, one on each side of the assembly.
b) Short the signal input terminals together.
c) Turn HIGH - LOW - STDBY - OFF switch to HIGH, and LOW - N - HIGH gear shifter to HIGH.
d) Adjust ZERO ADJUST control until pen balances in chart center.
e) Rotate DAMPING control to extreme clockwise position.
f) Twist servo motor shaft by hand until the pen moves 1/4 inch to one side or the other of the balance position. Allow shaft to return to balance position slowly, braking the return by holding the servo motor shaft.
g) Allow an inch of chart paper to unroll, then turn servo motor shaft in opposite direction, repeating (f), above.
h) Note the final position difference between the first trace and the second. This is the dead zone.

4.2.12 VOLTAGE TEST POINTS

Figure 4-7 shows voltages at tube socket pins. The voltages at V201 pins were taken from a Type A-21 Input Chassis and are typical of all chassis.

The servo amplifier gain control was fully counter-clockwise, and the signal inputs were strapped together. An -hp- 410B VTVM was used, and all voltages were measured with respect to amplifier floating ground, that is, the input ground terminal was not strapped to chassis ground.

Access to V201 in the input chassis may be gained by using the test connector 970777, or by removing the bottom of the recorder. Other tube pins are accessible from the top of the servo amplifier printed circuit board. Voltages shown are ±10%. Pins 3 and 8 of V201 and V302 are always approximately one volt positive with respect to pins 2 and 7 for proper grid bias. If a positive voltage appears at pins 2 and/or 7, the tube may be gassy, or capacitors C206 or C302 may be leaky. If the voltages at pins 3 and 8 of V201 and V302 are significantly lower, tubes may be weak. In this case voltages at pins 1 and 6 will probably be higher. V302 may show a small a-c voltage at pin 2, the grid. This is normal. A large a-c voltage can be reduced by adjusting the hum balance control.

4.2.13 POWER SUPPLIES

Low B+ voltage and excessive ripple can usually be traced to faulty diodes. Complete power supply failure indicates shorted diodes and filter capacitors. If a power supply channel fails, all *diodes* and the *filter capacitor* should be replaced.

TUBE	PIN ①	②	③	④	⑤	⑥	⑦	⑧	⑨
V201	120v	0.0v	1v	3.2vAC	3.2vAC	130v	0.0v	1.2v	3.2vAC
V302	135v	0.0v	1.4v	3.2vAC	3.2vAC	142v	0.0v	1.4v	3.2vAC
V303	0.0v	15v	3.2vAC	3.2vAC	260v	267v	0.0v		

Figure 4-7: Voltage at Tube Socket Pins

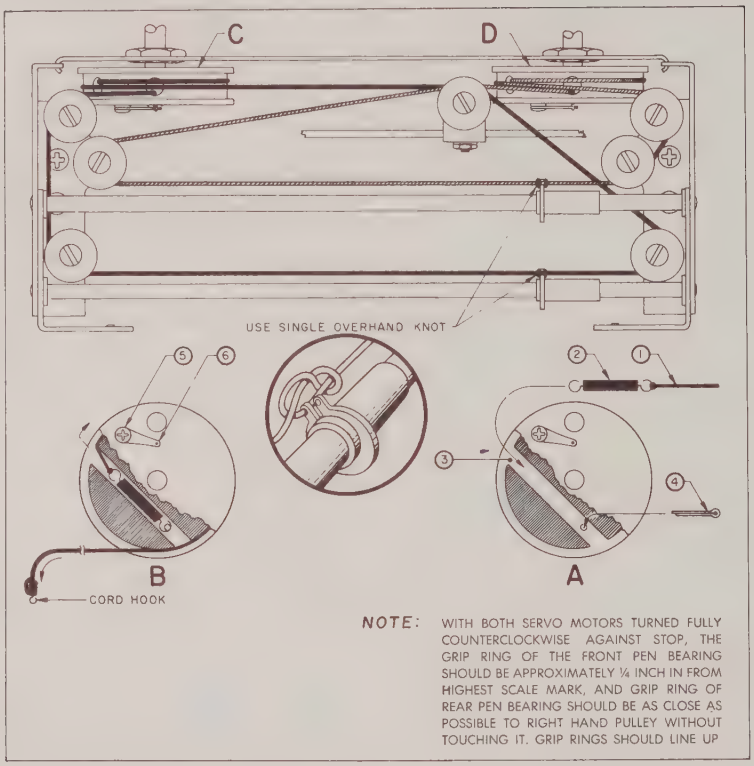

C
D
USE SINGLE OVERHAND KNOT
5
6
2
1
3
4
B
A
CORD HOOK
NOTE: WITH BOTH SERVO MOTORS TURNED FULLY COUNTERCLOCKWISE AGAINST STOP, THE GRIP RING OF THE FRONT PEN BEARING SHOULD BE APPROXIMATELY ¼ INCH IN FROM HIGHEST SCALE MARK, AND GRIP RING OF REAR PEN BEARING SHOULD BE AS CLOSE AS POSSIBLE TO RIGHT HAND PULLEY WITHOUT TOUCHING IT. GRIP RINGS SHOULD LINE UP

Figure 4-8: Dial Cord Stringing Procedure

4.3 PERFORMANCE CHECKS AND ADJUSTMENT OF MECHANICAL UNITS

4.3.1 DIAL CORD ADJUSTMENT

To adjust the dial cord, proceed as follows:

a) Remove the recorder from its case by loosening the two captive screws, one on each side of the assembly.

b) See Figure 4-8, item #5, the dial-cord adjusting screw. Rotate the servo motor shaft fully counterclockwise until the screw is at its uppermost position.

c) Raise chart scale. Loosen dial-cord adjusting screw. (Dial-cord tension is maintained by a spring inside the drum which is fastened to one end of the dial cord and secured to the drum by a cotter pin.)

d) Adjust dial-cord tension by rotating the dial cord adjusting arm, item #6, until the coils of the tension spring are approximately 3/4 inch from the hole opening in the sheave. Secure the adjusting screw. To loosen, allow spring tension to pull dial cord in opposite direction.

4.3.2 DIAL CORD STRINGING

The following steps cover dial cord stringing and apply to both channels.

a) Refer to Figure 4-8. Tie one end of dial cord (#1) to (#2). Use square knot. Slide spring into hole (#3). Insert cotter pin (#4) through intersecting hole in sheave and spring eye. Flatten cotter pin against back of sheave.

b) Wind a full turn of cord on the sheave in a clockwise direction, as in Figure 4-8b. Refer to either Figure 4-8c or 4-8d for stringing details of front-pen or rear-pen dial cord, respectively.

c) Rotate servo motor shaft fully counterclockwise until motor stop strikes bumper.

d) Tie dial cord to lower hole in pen bearing grip ring using a single overhand knot. For the front pen bearing, the grip ring should be approximately 1/4 inch in from the highest scale mark after tying. For the rear bearing, the grip ring should be as close as possible to the right hand pulley without touching it.

e) Follow Figure 4-8c or 4-8d for returning dial cord to sheave, whichever applies, feeding dial cord through remaining hole on top of the sheave. Bring the dial cord out through hole on front of sheave, and attach dial cord hook to adjusting arm. Adjust dial cord tension as described in Section 4.3.1(d).

4.3.3 BALANCING POTENTIOMETER

If the balancing potentiometer becomes "noisy", excessive deadband, "chattering" or a recurring transient at one particular point on the chart will occur. "Noise" is due to intermittent wiper contact resulting from dirt and wear. For best system performance the potentiometer should be replaced. Due to the precision of balancing potentiometers used in the Model G-22 Recorder, disassembly for maintenance and cleaning should be undertaken *only by experienced persons,* or by authorized Varian Service Representatives. The following instructions cover potentiometer removal and replacement:

a) Refer to Figure 4-9. Loosen the dial-cord sheave from the balancing potentiometer shaft by loosening the two Allen-head set screws.

b) Loosen the flexible shaft coupler between servo motor and potentiometer shaft by loosening the two Allen-head set screws in each half. Slide the flexible shaft coupler onto the servo motor shaft.

c) Unfasten the leads to the potentiometer, noting the lead location.

d) Remove the potentiometer mounting nut and lockwasher, and remove potentiometer and shaft from recorder. Tape the sheave in place to keep the dial cord properly strung.

e) To replace the potentiometer, first assemble the potentiometer, its lockwasher, and mounting nut on the potentiometer mounting bracket, and position potentiometer so that its terminals are in their uppermost position. Secure mounting nut. Slide sheave onto potentiometer shaft. Do not secure.

f) Fasten leads to potentiometer in their original positions.

g) Slide flexible shaft coupler onto potentiometer shaft, but do not secure. The potentiometer is now installed. It will be necessary to phase the potentiometer as covered in Section 4.3.4 below.

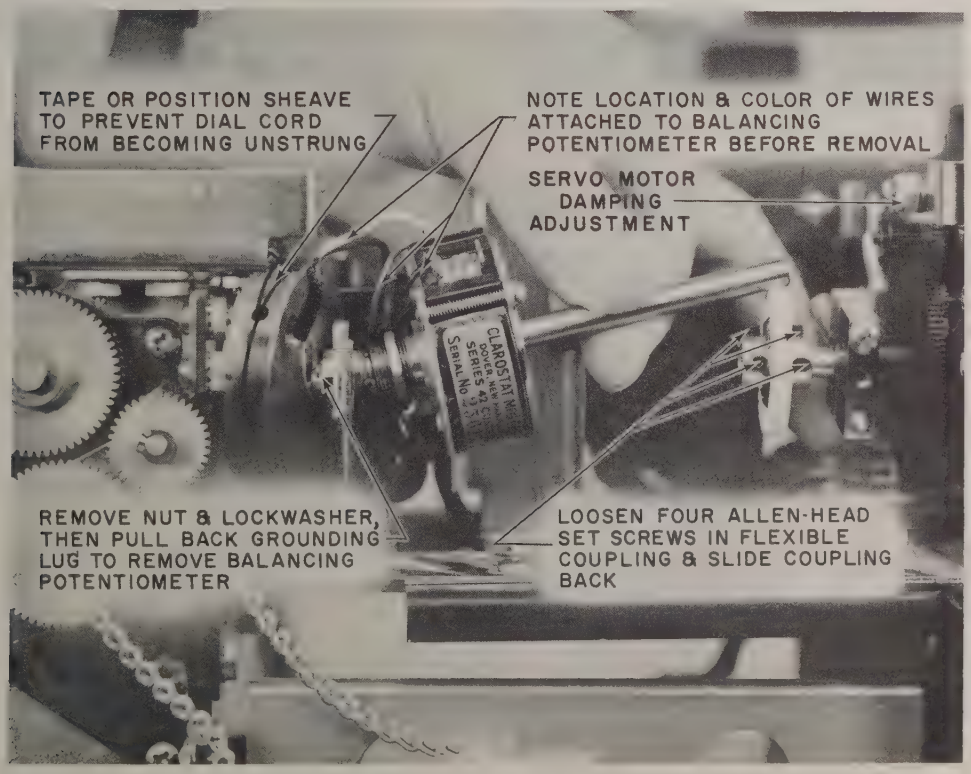

TAPE OR POSITION SHEAVE TO PREVENT DIAL CORD FROM BECOMING UNSTRUNG
NOTE LOCATION & COLOR OF WIRES ATTACHED TO BALANCING POTENTIOMETER BEFORE REMOVAL
SERVO MOTOR DAMPING ADJUSTMENT
REMOVE NUT & LOCKWASHER, THEN PULL BACK GROUNDING LUG TO REMOVE BALANCING POTENTIOMETER
LOOSEN FOUR ALLEN-HEAD SET SCREWS IN FLEXIBLE COUPLING & SLIDE COUPLING BACK

Figure 4-9: Balancing Potentiometer Removal

4.3.4 BALANCING POTENTIOMETER PHASING

To phase the balancing potentiometer, proceed as follows:

a) See that potentiometer terminals are in their uppermost positions.
b) If not already loose, loosen the two Allen-head set screws in the flexible shaft coupler and in the sheave.
c) Viewing recorder from front, rotate servo motor counterclockwise until the stop rests against the rubber bumper. Turn sheave so pen is positioned at zero.
d) Measure the resistance across the potentiometer wiper and the counterclockwise terminal.
e) Rotate potentiometer shaft counterclockwise. Resistance across wiper and counterclockwise terminal will decrease. When a resistance reading of 100 ohms ±10% is reached, make sure that the servo motor and sheave are in the positions of step (c) above, and tighten the set screws in the flexible shaft coupler and in the sheave.

4.3.5 SERVO MOTOR DAMPING ADJUSTMENT

The servo motor damping adjustment is shown in Figure 4-9. This is a factory adjustment and *should not* require readjustment. Correct tension will provide a servo motor starting torque of from 14 to 16 ounce-inches with the flexible shaft coupler disconnected.

4.3.6 CHART DRIVE MOTORS

Location of chart drive motors is shown in Figure 4-10. Normally a chart drive motor will not require replacement unless a change in motor speed is required. To remove and replace a chart drive motor, proceed as follows:

a) Unplug recorder from a-c line.
b) Refer to Figure 2-3. Remove the drive chain by loosening the tension idler and slipping drive chain from sprockets.
c) Remove power supply chassis retaining screw and remove power supply.
d) Carefully note location of motor power leads on terminal strip TB501 at rear of recorder frame, and disconnect leads.
e) Remove motor mounting screws, and remove motor.
f) To replace motor, assemble in reverse order, observing correct placement of motor leads on terminal strip. View the terminal strip TB501 from the rear of the recorder. Each of the four terminal strip sections has two screws. Connections to the four terminal-section screws nearest the front of the recorder are from left to right: (1) low-speed motor power, (2) a-c common for both low- and high-speed motors, (3) high-speed motor power, and (4) violet wire from cable. Connections to the terminal section screws nearest the rear of the recorder are from left to right (laced in the same loom) (1) gray, (2) violet, and (3) yellow. Terminal section (4) is a-c line white.

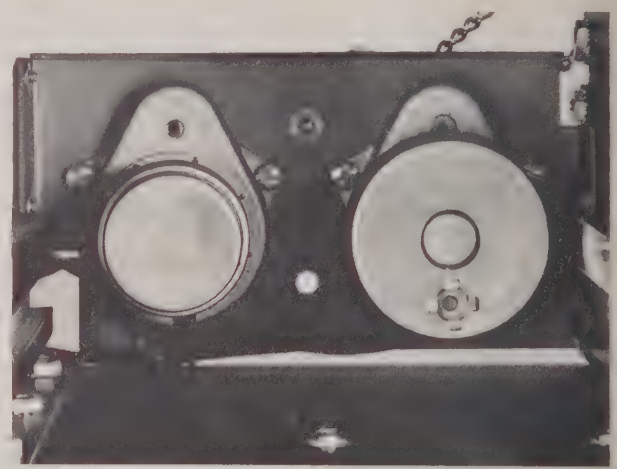


Figure 4-10: Location of Chart Drive Motors (Power Supply Removed)

4.3.7 DRIVE CHAIN ADJUSTMENT

There is one adjustment of the drive chain. This is the tension adjustment made by loosening the tension idler, shown in Figure 2-3, and repositioning it to provide the desired tension. Excessive tension will overload the chart drive motor. NOTE: Overloading the high-speed motors will cause a clattering noise, but no damage. Overloading the low-speed motors may cause severe damage, requiring complete motor replacement.

4.3.8 CHART PAPER TENSION

The Model G-22 employs a slip-belt to maintain chart tension over the platen. Because chart tension depends upon belt tension, wear or stretching of the belt will reduce chart tension, and will require belt replacement. See Figure 4-11.

4.3.9 LUBRICATION

The G-22 requires occasional cleaning and oiling. Figure 4-12 shows the lubrication points. Do not over-lubricate. Excess oil merely holds dust and dirt and can be harmful. Light machine oil or S.A.E. 10W motor

oil is recommended. DO NOT lubricate the pen bearings or the pen shafts. The pen bearing supplies its own lubrication. If binding of the pen bearings on the pen shaft occurs, clean the shafts thoroughly with an oil solvent.

4.3.10 PEN SYSTEM

India or non-water soluble inks should not be used with the capillary pens. If the recorder is to be stored, pens and capillary feed tubes should be flushed with warm water.

Pens snap onto their pen bearings by clips, and may be removed by slipping capillary feed tubes from pen tubes, and sliding pens from pen bearings. When replacing pens, move the front pen to the left-hand chart margin, and the rear pen to the right-hand chart margin and see that the lower holes in the pen-bearing grip rings through which the dial cords are fastened line up with the dial-cord pulleys. If pens are installed so that grip rings are too high or too low, improper pen contact with the chart will occur.

4.4 TROUBLESHOOTING CHART

The Troubleshooting Chart, pages 4-12 and 4-13, lists possible troubles. Remember that G-22 modular construction provides troubleshooting shortcuts by allowing the components of an operative channel to be substituted for those of an inoperative channel until the general location of the difficulty is discovered. Full use should be made of this technique, as considerable time can be saved. The troubleshooting chart can then be used to determine the nature and cause of the difficulty.

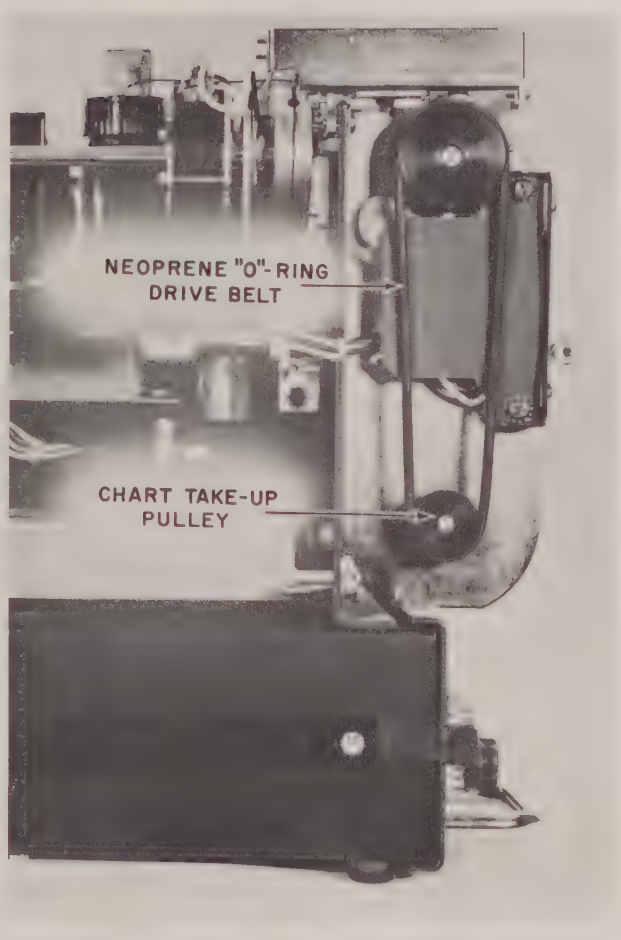


Figure 4-11: Chart Takeup Drive

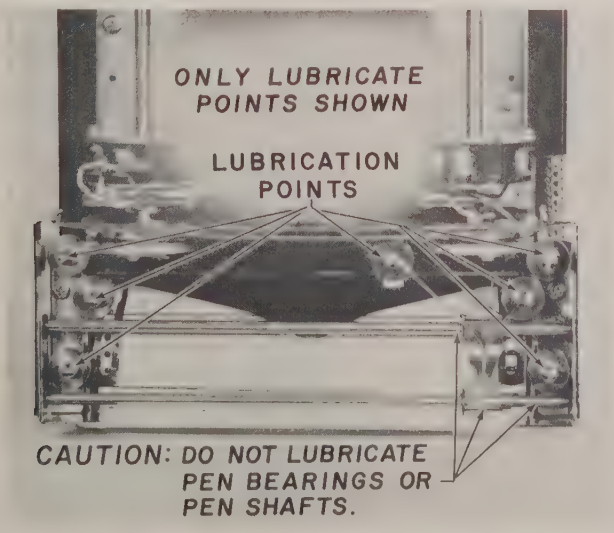


Figure 4-12: Lubrication Points

TROUBLESHOOTING CHART

SYMPTOM	CAUSE	REMEDY
One or both recorder channels without power	Blown fuse	Replace fuse
Chart paper will not advance	Pen bearings rotated, pen holds chart	See Section 4.3.10
	Gear shifter in "N" position	Place gear shifter in HIGH or LOW
	Chart drive motor disconnected at terminal strip TB501	Make proper connection
	Drive gear loose on shaft	Tighten set screw
	Drive motor gear train inoperative	Replace drive motor
Chart paper loose over platen	Slots in left end of reroll tube disengaged	Engage
	Stretched take-up belt	Replace belt
Improper ink feed	Clogged pens	Clean with warm water
	Poor pen contact on chart	See Section 4.3.10
	Wrong type of ink	Empty system, rinse, and refill with recommended type
	Ink reservoirs mounted too high or too low	Reposition
	Bubbles in capillary tubes	Blow air through inlet tube in ink reservoir, or use priming tube
Servo motor drives against mechanical stop and will not null	Servo, and potentiometer improperly phased	See Section 4.3.4
	Discharged reference cell	Replace reference cell
	Chopper inoperative	Replace chopper. See Section 4.2.3
	Input open	Check continuity
	Improper signal connections	See Sections 3.3 and 3.3.1
	V201 inoperative, or wrong tube	Switch input chassis. See Section 4.2.9
Cannot calibrate	Reference cell discharged	Replace reference cell
	Input signal exceeds full span range	See Section 4.2.9
Cannot adjust zero to chart edge	Instrument improperly calibrated	Calibrate. See Section 4.2.7
	Reference cell low	Replace reference cell
	Span improperly adjusted	See Section 4.2.9

SYMPTOM	CAUSE	REMEDY
ZERO ADJUST CONTROL very one-sided for proper zero position of pen with signal input connected	Recorder not grounded or improper signal connections	See Sections 3.3 and 3.3.1
	Servo and potentiometer improperly phased	See Section 4.3.4
System insensitive, large dead band	Chopper operation poor	See Section 4.2.3
	Servo amplifier gain low	Adjust. See Section 4.2.4
	Source impedance too high	See Section 3.3
	Low line voltage	
Recorder cannot be properly damped	Mechanical damper setting incorrect	See Section 4.3.5
	Excessive servo amplifier gain	Adjust. See Section 4.2.4
	Dirty potentiometer	Replace. See Section 4.3.3
	Incorrect span adjustment	See Section 4.2.9
Excessive balancing time	Low servo amplifier gain	Adjust. See Section 4.2.4
	Excessive dial-cord tension	See Section 4.3.1
	Source impedance too high	See Section 3.3
	Mechanical damper setting incorrect	See Section 4.3.5
Pen oscillates	Excessive servo amplifier gain	Adjust. See Section 4.2.4
Pen "jitters" at a given point on chart	Dirty potentiometer	Replace. See Section 4.3.3
Full-span sweep across chart curved or irregular	Bind, or dirt in mechanical system	Check chart drive chain and clean pen rods
	Shorted potentiometer windings	Replace. See Section 4.3.3
Positive-going signals cause right-to-left pen travel	Reference cell installed backwards	Install correctly
Operator receives shock from recorder	Recorder not grounded	See Section 3.2
Intermittent, irregular transients	Severe line disturbances	Use line filter, isolation transformer
Line fuse blows, no B+	Shorted rectifier diodes or capacitors	See Section 4.2.13 and Figure 5-11

parts list

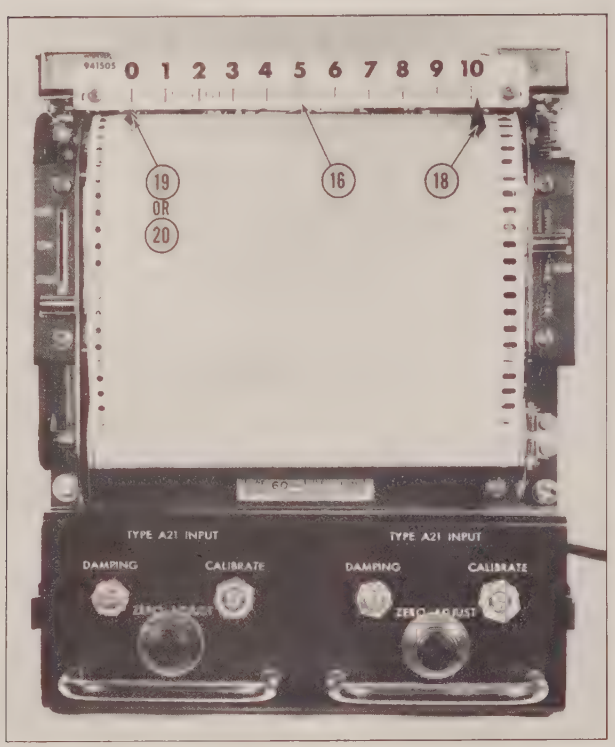


Figure 5-1: Front View of Recorder

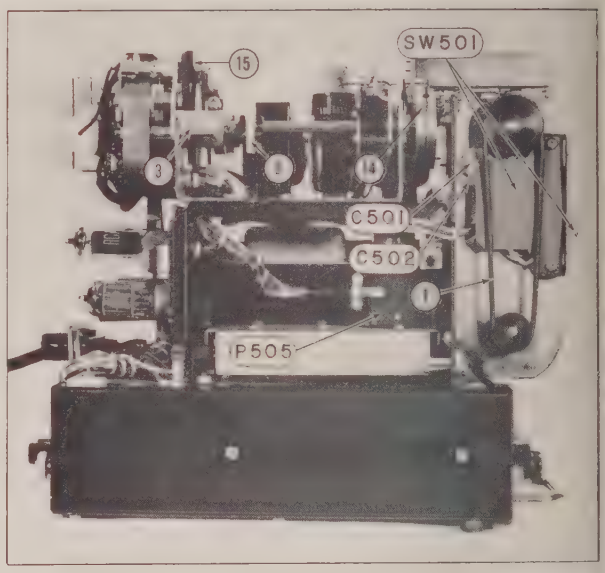


Figure 5-3: L/H Side View of Recorder

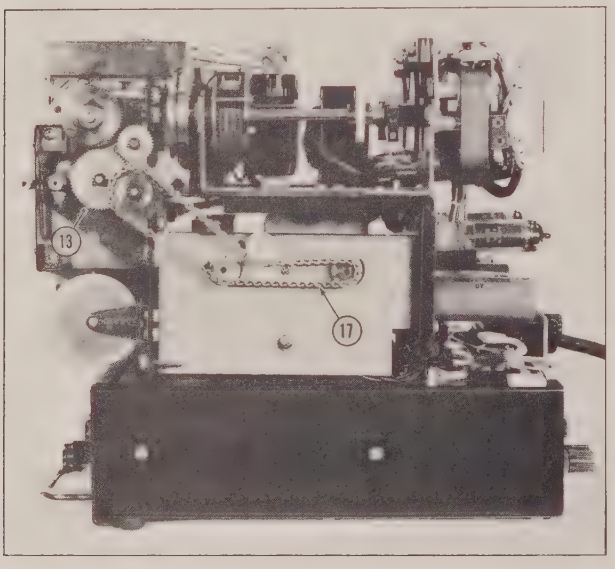


Figure 5-2: R/H Side View of Recorder

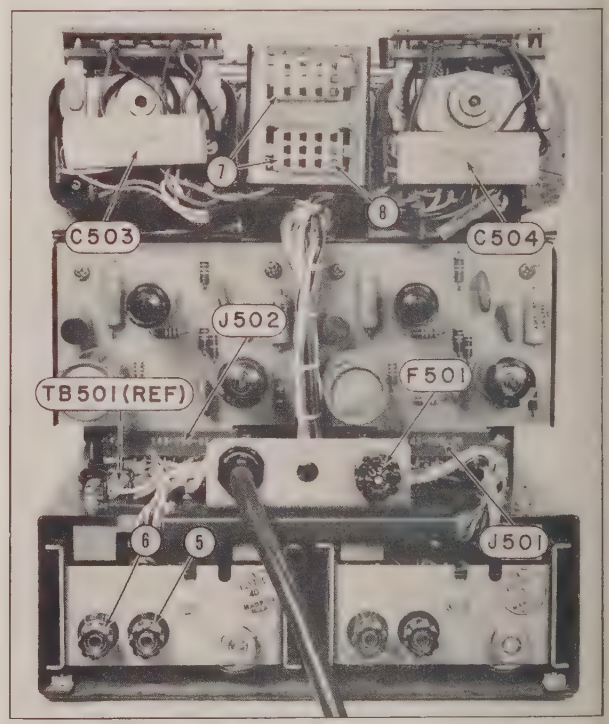


Figure 5-4: Rear View of Recorder

MAIN RECORDER ASSEMBLY

Schematic Reference	*Part Description*	*Manufacturer's Designation*	*Varian Part Number*
C501, C502	Capacitor, fixed, ceramic, .02 μf, 600 vdc	Centralab DD-203	41-269-889
C503, C504	Capacitor, fixed, Mylar, .68 μf, 400 vdc	Gudeman 338E684M	41-749-889
F501	Fuse, 1a, 250v, 3AG	Littlefuse	
	Fuse Holder for 3AG size fuses	Littlefuse 342003	55-198-998
P505	Plug, 12-contact female	Cinch S-312CCE	51-209-712
J506, J507	Amp Lok 12-circuit plug	AMP C-480087	51-308-112
J501, J502, J503, J504	Receptacle, 10-contact	Amphenol 143-010-01	51-408-410
R501, R502	Resistor, Variable, ww, 3k		941876
SW501	Lever switch, shorting type		941873
	Test chassis (optional)		970777
	Pen primer		89-999-500

MECHANICAL PARTS LIST

Ref. No.	*Part Description*	*Varian. No.*
1	Belt	20-489-990
2	Coupling, flexible	20-269-990
3	Latex tubing	88-459-990
4	Potentiometer mounting plate	904217
5	See J202 in input chassis parts list	
6	See J201 in input chassis parts list	
7	See J506, J507, Main Recorder Assembly parts list	
8	Contact insert for J506, J505	51-909-930
9	Cord tension spring	903461
10	Ink bottle assembly	904120
11	Dial cord	88-589-990
12	Cord hook	901977
13	Mechanical chart-speed change assembly	903777
14	Sheave, dial-cord	903781
15	Damper assembly	904340
16	Scale (Refer to Section 2.7.2 for list of available scales)	
17	Drive chain	901327-04
18	Front pen replacement kit	904743-01
19	Rear pen replacement kit	904743-02
20	Rear pen, zero displacement	904743-03

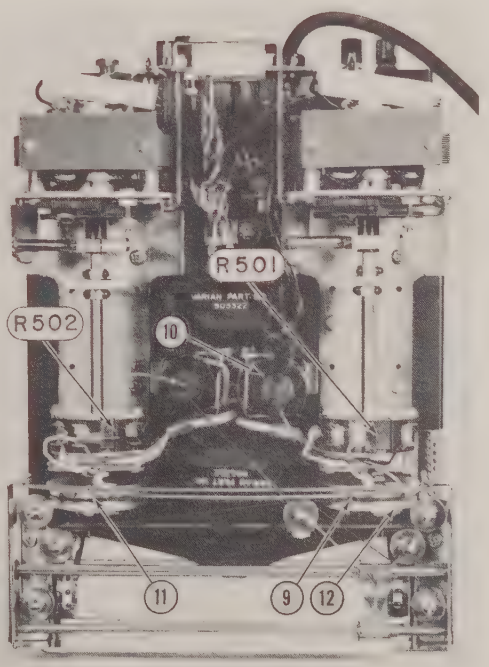


Figure 5-5: Top of Recorder

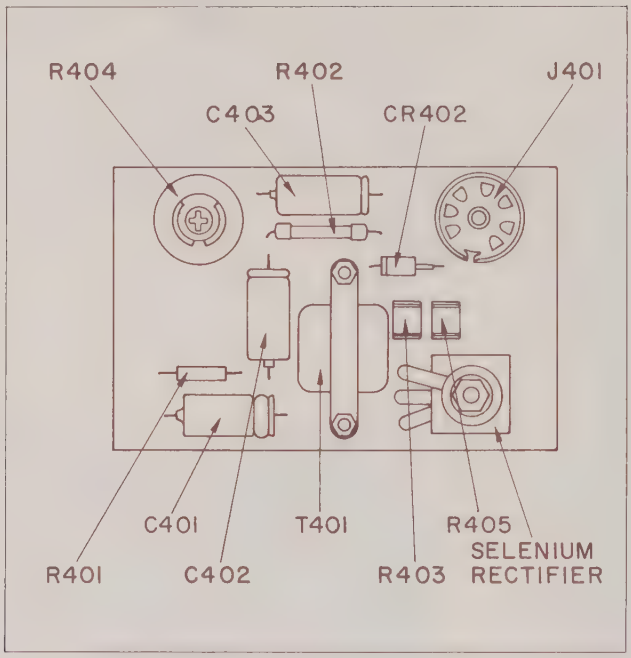


Figure 5-6: Electronic Reference Voltage Supply

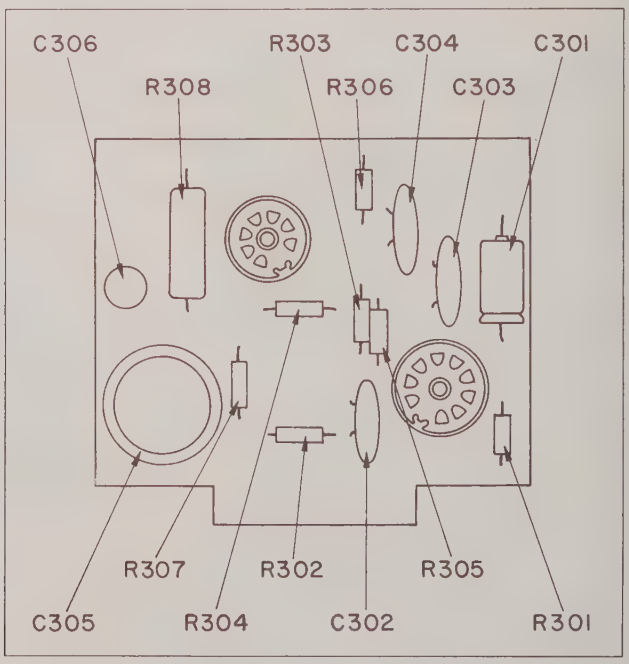


Figure 5-7: Servo Amplifier

ELECTRONIC REFERENCE SUPPLY

Schematic Reference	*Part Description*	*Manufacturer's Designation*	*Varian Part Number*
C401	Capacitor, fixed, electrolytic, 25 μf, 25 vdc	Barco P25-25	41-509-997
C402, C403	Capacitor, fixed, electrolytic, 50μf, 12 vdc	Barco P12-50	41-509-998
CR401	Rectifier, full-wave bridge, 100 ma, 40 vdc	International Rect. Co. 59-0822-2	66-230-199
CR402	Zener diode		904190
J401	Socket, connector, 7-pin miniature	Cinch 53P 22977	54-277-990
R401	Resistor, fixed, comp., 620 ohms, ½w, 5%	Allen Bradley EB	32-201-362
R402	Resistor, fixed, comp., 68.1 ohm, ½w, 1%	Electra DC ½A	31-672-681
R403	Resistor, fixed, ww, 10k, 2w, ½%		904200-01
R404	Resistor, variable, comp., 2.2k, ½w		942064
R405	Resistor, fixed, ww, 11.5k, 2w, ½%		904200-02
T401	Isolation transformer		941877

SERVO AMPLIFIER

Schematic Reference	*Part Description*	*Manufacturer's Designation*	*Varian Part Number*
C301	Capacitor, fixed, electrolytic, 80 μf, 6 vdc	Barco P6-80	41-509-999
C302, C303, C304	Capacitor, fixed, ceramic, .01 μf, 400 vdc	Electra EKC20E-103KC4	41-249-990
C305	Capacitor, fixed, electrolytic, 20 μf, 350 vdc	Cornell-Dublier SK8543	41-538-990
C306	Capacitor, fixed, electrolytic, 25 μf, 30 vdc	Cornell-Dublier ECPB711	41-508-780
R301	Resistor, fixed, comp., 4.7k, ½w, 10%	Allen-Bradley EB	32-202-447
R302	Resistor, fixed, comp., 330k, ½w, 10%	Allen-Bradley EB	32-202-633
R303	Resistor, fixed, comp., 470k, ½w, 10%	Allen-Bradley EB	32-202-647
R304	Resistor, fixed, comp., 330k, ½w, 10%	Allen-Bradley EB	32-202-633
R305	Resistor, fixed, comp., 4.7w, ½w, 10%	Allen-Bradley EB	32-202-447
R306	Resistor, fixed, comp., 470k, ½w, 10%	Allen-Bradley EB	32-202-647
R307	Resistor, fixed, comp., 47k, ½w, 10%	Allen-Bradley EB	32-202-547
R308	Resistor, fixed, comp., 500 ohms, 5 w, 5%		35-289-500
	Socket, 7-pin miniature	Cinch 53P 22977	54-277-990
	Socket, 9-pin miniature	Cinch 44P 22624	54-279-990

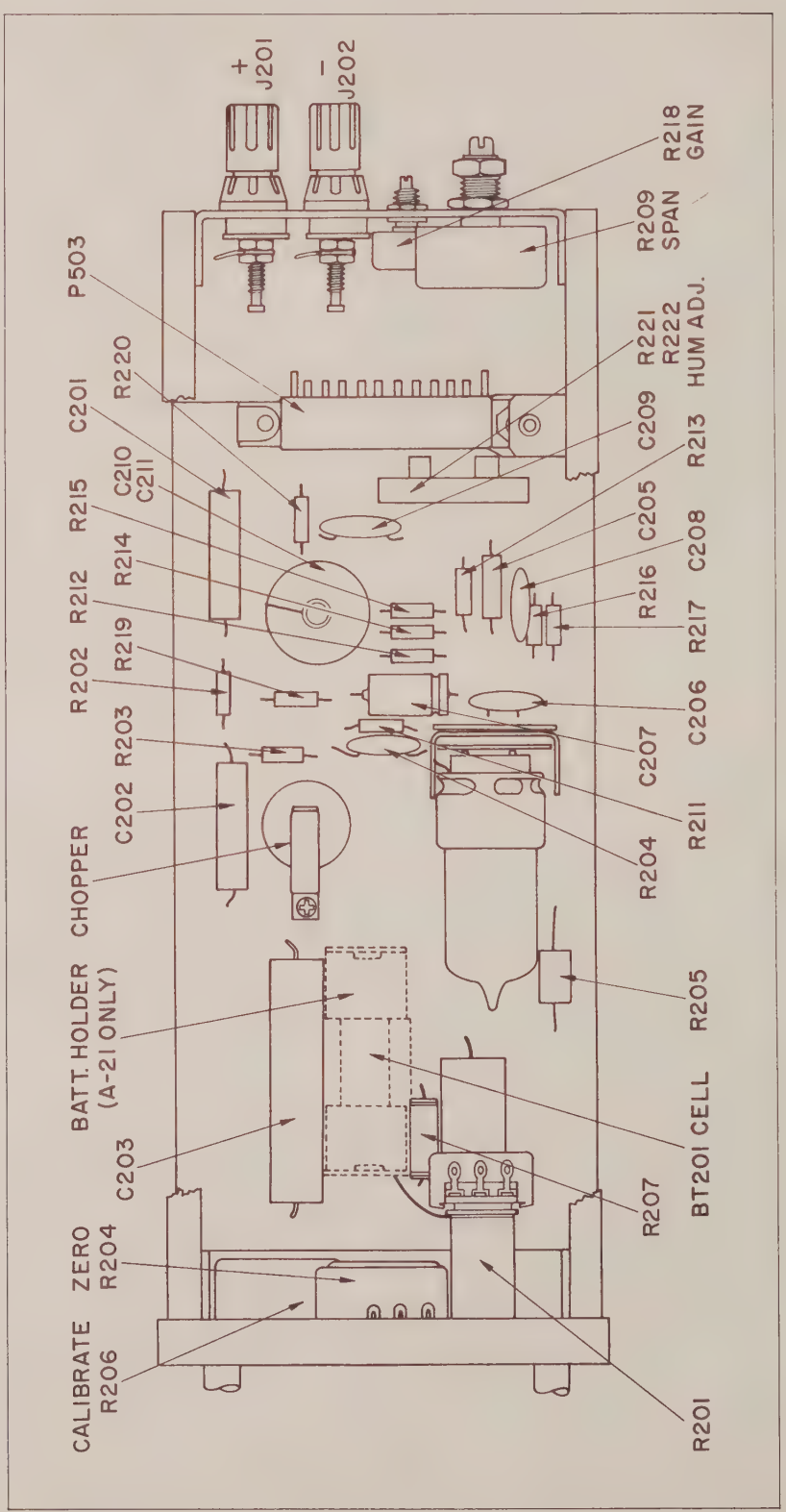


Figure 5-8: Type A-21 and A-22 Input Chassis

A21 AND A22 INPUT CHASSIS

Schematic Reference	*Part Description*	*Manufacturer's Designation*	*Varian Part Number*
BT-201	Battery Holder (Type A-21 only)	Austin Craft 127RM	55-399-980
	Battery, mercury reference cell (Type A-21 only)	Mallory RM 12R	74-101-550
	Cable Assy., 4-conductor and shield, with plug (Type A-22 only)		942055
C201, C202	Capacitor, fixed, Mylar, .5 μf, 150 vdc	Gudeman 13825	41-719-398
C203	Capacitor, fixed, Mylar, 1 μf, 200 vdc	Gudeman 338C105M	41-729-897
C204	Capacitor, fixed, ceramic, .01 μf, 400 vdc	Electra EKC20E-103KC4	41-249-990
C205	Capacitor, fixed, mica, 100 μμf, 500 vdc	Sangamo PR 1310	41-157-746
C206	Capacitor, fixed, ceramic, .01 μf, 400 vdc	Electra EKC20E-103KC4	41-249-990
C207	Capacitor, fixed, electrolytic, 80 μf, 6 vdc	Barco P6-80	41-509-999
C208, C209	Capacitor, fixed, ceramic, .01 μf, 400 vdc	Electra EKC20E-103KC4	41-249-990
C210, and C211	Capacitor, fixed, electrolytic, dual 10/10 μf, 350 vdc	Mallory PTCD-62	41-535-990
C212	Capacitor, fixed, Mylar, .25 μf, 200 vdc	Gudeman 338C254M	41-729-877
CH101	Chopper	Airpax 171	901335
P503	Connector, 10-contact	Amphenol 133-010-03	51-108-910
J201	Jack, single contact, red	Grayhill 29-2R	51-799-960
J202	Jack, single contact, black	Grayhill 29-2B	51-799-961
R201	Resistor, variable, comp., 150k, insulated shaft		904378
R202	Resistor, fixed, comp., 47k, ½w, 10%	Allen-Bradley EB	32-202-547
R203	Resistor, fixed, comp., 470k, ½w, 10%	Allen-Bradley EB	32-202-647
R204	Resistor, variable, ww, 5k, 2w	Clarostat 43C2-500	37-586-450
R205	Resistor, fixed, comp., 2k, ½w, 1%		904351-01
R206	Resistor, variable, comp., 5k, 2w	Allen-Bradley JAIL0405502UC	36-895-450
R207	Resistor, fixed, comp., 100k, ½w, 1%		904347-01
R209	Resistor, variable, ww, 20k, 2w	Clarostat 43C2-20K	37-586-520
R211	Resistor, fixed, comp., 470k, ½w, 10%	Allen-Bradley EB	32-202-647
R212	Resistor, fixed, comp., 2.2k, ½w, 10%	Allen-Bradley EB	32-202-422
R213	Resistor, fixed, comp., 10 meg, ½w, 10%	Allen-Bradley EB	32-202-810
R214	Resistor, fixed, comp., 220k, ½w, 10%	Allen-Bradley EB	32-202-622
R215	Resistor, fixed, comp., 470k, ½w, 10%	Allen-Bradley EB	32-202-647
R216	Resistor, fixed, comp., 1 meg, ½w, 10%	Allen-Bradley EB	32-202-710
R217	Resistor, fixed, comp., 6.8k, ½w, 10%	Allen-Bradley EB	32-202-468
R218	Resistor, variable, comp., 1 meg, 2w		903344
R219, R220	Resistor, fixed, comp., 47k, ½w, 10%	Allen-Bradley EB	32-202-547
R221, and R222	Resistor, variable, dual, comp., 5k, ¼w	Centralab EP 539	36-499-790
	Socket, 90 deg., 9-pin, with shield	Elco 4009-1-EG-1/16	54-279-980
	Grounding terminal		901515-02

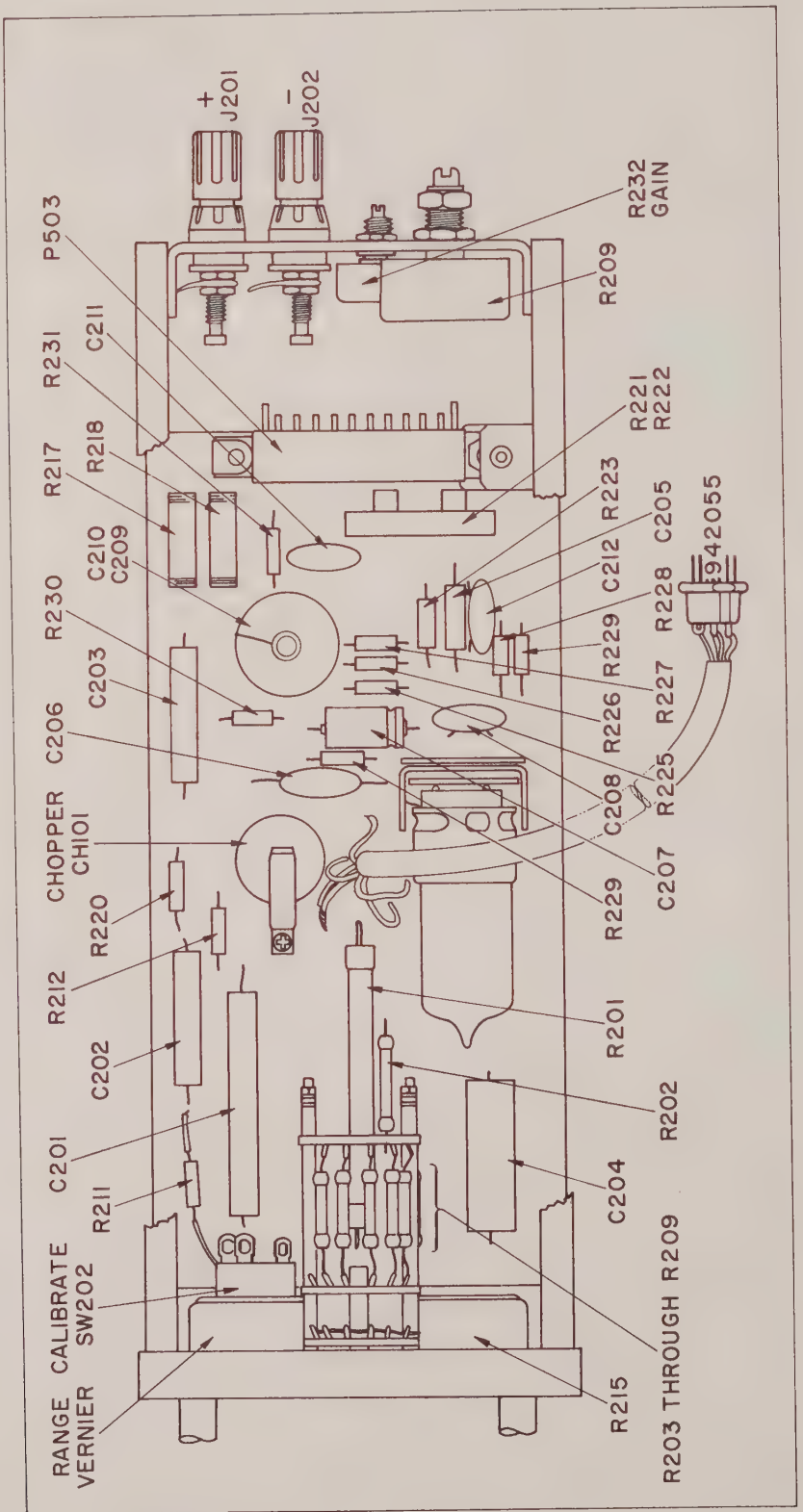


Figure 5-9: Type B-22 Input Chassis

B-22 INPUT CHASSIS

Schematic Reference	*Part Description*	*Manufacturer's Designation*	*Varian Part Number*
	Cable Assembly, 4-conductor and shield, with plug		942055
C201	Capacitor, fixed, Mylar, 1μf, 200 vdc	Gudeman 338C105M	41-729-897
C202, C203	Capacitor, fixed, Mylar, .5 μf, 150 vdc	Gudeman 13835	41-719-398
C204	Capacitor, fixed, Mylar, .25 μf, 200 vdc	Gudeman 338C254M	41-729-877
C205	Capacitor, fixed, mica, 100 μμf, 500 vdc	Sangamo PR-1310	41-157-746
C206	Capacitor, fixed, ceramic, .01 μf, 400 vdc	Electra EKC20E-103KC4	41-249-990
C207	Capacitor, fixed, electrolytic, 80 μf, 6 vdc	Barco P6-80	41-509-999
C208	Capacitor, fixed, ceramic, .01 μf, 400 vdc	Electra EKC20E-103KC4	41-249-990
C209, and C210	Capacitor, fixed, electrolytic, dual, 10/10 μf, 350 vdc	Mallory PTCD-62	41-535-990
C211, C212	Capacitor, fixed, ceramic, .01 μf, 400 vdc	Electra EKC20E-103KC4	41-249-990
CH101	Chopper	Airpax 171	901335
P503	Connector, 10-contact	Amphenol 133-010-03	51-108-910
J201	Jack, single contact, red	Grayhill 29-2R	51-799-960
J202	Jack, single contact, black	Grayhill 29-2B	51-799-961
R201	Resistor, fixed, comp., 9 meg, 2w, ½%	Electra DC-2	31-887-790
R202	Resistor, fixed, comp., 900k, ½w, ½%	Electra DC-½A	31-684-690
R203	Resistor, fixed, comp., 50k, ½w, ½%	Electra DC-½A	31-684-550
R204	Resistor, fixed, comp., 30k, ½w, ½%	Electra DC-½A	31-684-530
R205	Resistor, fixed, comp., 10k, ½w, ½%	Electra DC-½A	31-684-510
R206	Resistor, fixed, comp., 5k, ½w, ½%	Electra DC-½A	31-684-450
R207	Resistor, fixed, comp., 3k, ½w, ½%	Electra DC-½A	31-684-430
R208, R209	Resistor, fixed, comp., 1k, ½w, ½%	Electra DC-½A	31-684-410
R210	Resistor, variable, comp., 250k, 2w, with switch (SW 202)		904300
R211, R212	Resistor, fixed, comp., 47k, ½w, 10%	Allen-Bradley EB	32-202-547
R213	Resistor, fixed, ww, 2k, 2w, ½%		904351-01
R215	Resistor, variable, comp., 5k, 2w	Allen-Bradley JAIN04SP502UA	36-999-590
R216	Resistor, variable, ww, 20k, 2w	Clarostat 43C2-20K	37-586-520
R217	Resistor, fixed, ww, 91k, 2w, 1%		904347-02
R218	Resistor, fixed, ww, 1350 ohms, 2w, 1%		904351-02
R220	Resistor, fixed, 220k, ½w, 10%	Allen-Bradley EB	32-202-622
R221, and R222	Resistor, variable, dual, comp., 5k, ¼w	Centralab EP 539	36-999-790
R223	Resistor, fixed, comp., 10 meg, ½w, 10%	Allen-Bradley EB	32-202-810
R224	Resistor, fixed, comp., 470k, ½w, 10%	Allen-Bradley EB	32-202-647
R225	Resistor, fixed, comp., 2.2k, ½w, 10%	Allen-Bradley EB	32-202-422
R226	Resistor, fixed, comp., 220k, ½w, 10%	Allen-Bradley EB	32-202-622
R227	Resistor, fixed, comp., 470k, ½w, 10%	Allen-Bradley EB	32-202-647
R228	Resistor, fixed, comp., 1 meg, ½w, 10%	Allen-Bradley EB	32-202-710
R229	Resistor, fixed, comp., 6.8k, ½w, 10%	Allen-Bradley EB	32-202-468
R230, R231	Resistor, fixed, comp., 47k, ½w, 10%	Allen-Bradley EB	32-202-547
R232	Resistor, variable, comp., 1 meg		903344
	Socket, 90 deg., 9-pin, with shield	Elco 4009-1-EG-1/16	54-279-980
	Grounding terminal		901515-02

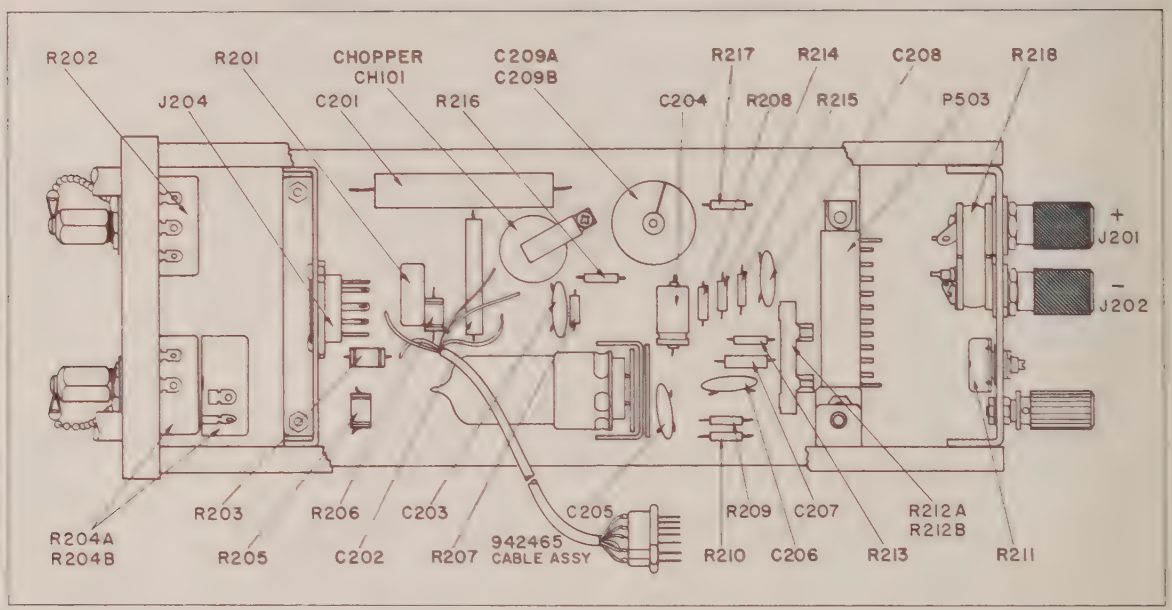


Figure 5-10: Type T-22 Input Chassis

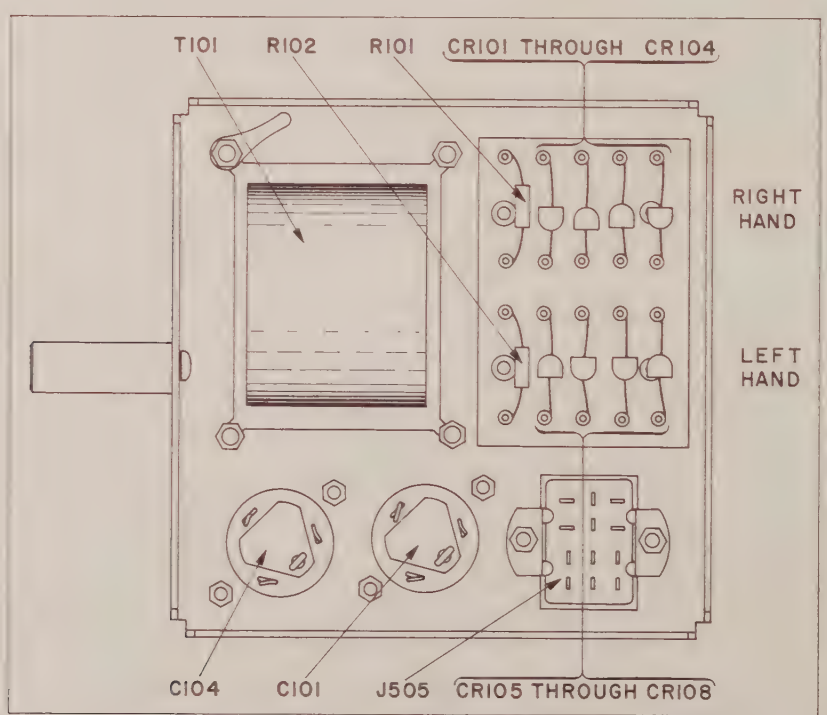


Figure 5-11: Power Supply

T-22 INPUT CHASSIS

Schematic Reference	*Part Description*	*Manufacturer's Designation*	*Varian Part Number*
C201	Capacitor, fixed, mylar, 1 μf, 200v	Gudeman 338C105M	41-729-897
C202	Capacitor, fixed, mylar, .25 μf, 200v	Gudeman 338C254M	41-729-877
C203	Capacitor, fixed, ceramic, .01 μf, 400v	Electra EKC20E 103KC4	41-249-990
C204	Capacitor, fixed, electrolytic, 80μf, 6v	Barco, Inc. P6-80	41-509-999
C205, C206	Capacitor, fixed, ceramic, .01 μf, 400v	Electra EKC20E 103KC4	41-249-970
C207	Capacitor, fixed, mica, 100 μμf, 500v	Sangamo PR 1310	41-157-746
C208	Capacitor, fixed, ceramic, .01 μf, 400v	Electra EKC20E 103KC4	41-249-990
C209A and C209B	Capacitor, fixed, dual electrolytic, 10/10 μf, 350v	Mallory PTCD-62	41-535-990
CH101	Chopper	Airpax 171	901335
P503	Connector, 10-contact	Amphenol 133-010-03	51-108-910
	Terminal knob		904550
J204	Socket, 9-pin miniature, modified		903742
R201A and R201B	Resistor, dual, voltage dividing network		903414
R202	Resistor, variable, ww, 5k, 2w	Clarostat 43C2-500	37-586-450
R203	Resistor, fixed, ww, 7.8k, ¼w, 1%		904351-03
R204A and R204B	Resistor, variable, dual, 500 ohm		903340
R205	Resistor, fixed, ww, 2k, ¼w, 1%		904351-01
R206	Resistor, fixed, ww, 100k, ¼w, 1%		904347-01
R207	Resistor, fixed, comp., 470k, ½w, 10%	Allen-Bradley EB	32-202-647
R208	Resistor, fixed, comp., 2.2k, ½w, 10%	Allen-Bradley EB	32-202-422
R209	Resistor, fixed, comp., 1 meg, ½w, 10%	Allen-Bradley EB	32-202-710
R210	Resistor, fixed, comp., 6.8k, ½w, 10%	Allen-Bradley EB	32-202-468
R211	Resistor, variable, comp., 1 meg		903344
R212A and R212B	Resistor, variable, dual, comp., 5k, ½w	Centralab EP 539	36-999-790
R213	Resistor, fixed, comp., 10 meg, ½w, 10%	Allen-Bradley EB	32-202-810
R214	Resistor, fixed, comp., 220k, ½w, 10%	Allen-Bradley EB	32-202-622
R215	Resistor, fixed, comp., 470k, ½w, 10%	Allen-Bradley EB	32-202-647
R216, R217	Resistor, fixed, comp., 47k, ½w, 10%	Allen-Bradley EB	32-202-547
R218	Resistor, Compensator assembly		904728
	Socket, 90 deg., 9-pin, with shield	Elco 4009-1-EG-1/16	59-279-980
	Grounding terminal		901515-02

POWER SUPPLY

Schematic Reference	*Part Description*	*Manufacturer's Designation*	*Varian Part Number*
C101, C104	Capacitor, fixed, electrolytic, 20 μf, 450 vdc	Cornell-Dublier AO460	41-548-194
CR101 thru CR108	Diode, Silicon	Sarkes-Tarzian F4, Silicon	66-397-937
J505	Connector, 12-contact, male	Cinch P312FP	51-309-712
R101, R102	Resistor, fixed, comp., 220k, ½w, 10%	Allen-Bradley EB	32-202-622

WARRANTY STATEMENT

Recorder products manufactured by Varian Associates are warranted to be free of defects in materials and workmanship for a one-year period beginning with the shipping date of the equipment. Expendable parts, i.e., mercury cells, fuses, and vacuum tubes, are excluded from liability. Liability under this warranty is limited to service, adjustment, or defective parts replacement.

Terms of the warranty are: (1) notification of the malfunction or irregularity must be received by Varian Associates, Instrument Division, 611 Hansen Way, Palo Alto, Calif., or an authorized representative within the warranty period. A full description of difficulties encountered, the equipment serial number, the date of shipment, and from whom purchased should be included; (2) the product must be determined by Varian Associates or its representative to have become defective through no fault of the user. On receipt of shipping instructions from Varian Associates or its representative, the user should ship the equipment, prepaid, via Railway Express, Air Freight, or motor van to the address specified. If the warranty has expired or become invalid through equipment misuse, an estimate of repair costs will be submitted before repairs are undertaken. Return shipping costs will be billed.

RECEIPT OF DAMAGED EQUIPMENT

Equipment should be thoroughly inspected on receipt. If damaged, notify carrier claim agent. He will provide instructions and forms for reporting and describing the damage. Notify Varian Associates, enclosing one copy of the claim form. Include pertinent data as stated in the warranty. Do not attempt to operate the equipment if damaged.

If the equipment fails to function properly, but has received no apparent physical damage, the stated equipment warranty applies, except that Varian Associates assumes all shipping costs if notification of malfunction is received at the above address within two weeks from the date of receipt.

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